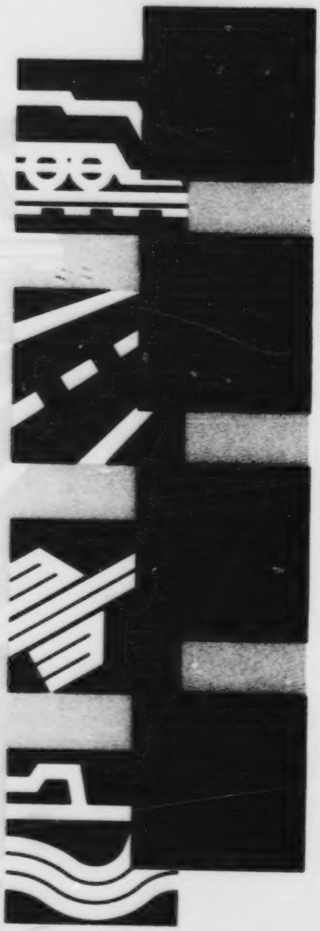
Transport Canada Transports Canada

TP 1936E

TDC
Project Directory



1982

Transportation
Development Centre

Transports Canada
Centre de développement des transports
1000 o., rue Sherbrooke
Suite 2421
Montréal, Québec. H3A 2R3
Télex 05-24713

Transport Canada
Transportation Development Centre
1000 Sherbrooke St. W.
Suite 2421
Montreal, Quebec. H3A 2R3
Telex 05-24713

Votre référence Your file

Notre référence Our file
D 2204-8-3

le 9 février 1983

J'ai le plaisir de vous faire parvenir l'édition 1982 du "CDT Répertoire des projets", une publication annuelle où sont décrites les principales activités du Centre de développement des transports (CDT), de Transports Canada. J'espère que vous trouverez ce document aussi intéressant qu'utile.

Veuillez utiliser la carte-réponse incluse à la fin du répertoire pour signaler les changements d'adresse ou faire les corrections nécessaires. Vous pourrez aussi l'utiliser pour nous suggérer le nom de personnes susceptibles de s'intéresser à notre répertoire.

Nous accueillerons avec plaisir tout commentaire ou toute demande que vous voudrez bien nous adresser concernant notre répertoire.

February 9, 1983

It is my pleasure to present the 1982 edition of the "TDC Project Directory", an annual publication describing the current activities of Transport Canada's Transportation Development Centre (TDC). I believe you will find the directory an informative and useful reference.

Please use the mailing card attached at the end of the directory to inform us of any changes or corrections to your address. You are also invited to use this card to suggest the names of colleagues who would be interested in the directory.

Any comments regarding this publication or requests for further information on TDC's program are most welcome.

Le directeur exécutif

Peter L. Eggleton

Peter L. Eggleton
Executive Director

Canada

TDC
Project Directory

1982

**Transportation
Development Centre**

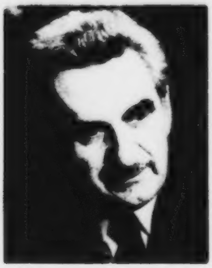
Transport Canada

Montreal, Quebec

Department of Supply and Services
Catalogue No. T48-17/1982E
ISBN: 0-662-12282-8

Également disponible en
français sous le titre
"CDT Répertoire des projets"
No. de catalogue T48-17/1982F

Preface



Minister
Transport Canada

Ministre
Transports Canada

The role of the Transportation Development Centre is to promote and develop advanced technology for Canadian transportation. The benefits of this activity are threefold.

First, new and more productive technologies can improve investment returns. This is especially important when industry and government are faced with a scarcity of capital.

Second, the development of better transportation systems reduces Canada's dependence on foreign suppliers, and improves its export opportunities.

Third, technology improvements can lead to greater safety in passenger and freight transportation.

The Transportation Development Centre plays a lead role in undertaking the required research programs, with participation from other units of Transport Canada, other federal departments, provincial governments, carriers and manufacturers.

It will be clear from the contents of this directory that although major results have been achieved, much work lies ahead. I take this opportunity to encourage the continued support and cooperation of all elements of the Canadian transportation sector.

Jean-Luc Pepin

Foreword

Transport Canada | Transports Canada

Transportation Development Centre | Centre de développement des transports

This is the sixth in a series of annual project directories describing projects and other significant activities of the Transportation Development Centre (TDC). This volume covers selected projects active during the reporting period of July 1981 to May 1982.

The projects described cover every phase of the innovation cycle in new transportation technology, that is: concept definition, prototype design and development, and pre-production demonstration leading to operational deployment in revenue service. The directory is organized according to the principal thrust areas of TDC's research and development program in transportation technologies: rail, surface, air and marine.

The diversity of the R&D activities described is a measure of TDC's ability to respond to the changing needs and opportunities presented by Canada's transportation systems. Distributed throughout the transportation community, the directory has in the past prompted comment on the nature and orientation of TDC's R&D program. We hope this lively response will continue, as it is through dialogue with our transportation partners that TDC's program is analyzed and strengthened.

I therefore present to you the 1982 edition of the directory and look forward to your response to the R&D activity it describes.

Peter L. Eggleton

Peter L. Eggleton,
Executive Director

Table of Contents

Introduction 1

TDC Publications 3

Railway Technology 7

Railway Electrification 9

- Cartier Railway Electrification Demonstration Study 10
- BC Rail Electrification Study 11
- Standards Study for Railway Electrification 12
- Power Supply Factors in Railway Electrification 13
- Signal System Design for Electrified Section of Cartier Railway 14
- Energy Storage System for Railway Electrification 15
- Catenary Mast Tests 16

Track/Train Dynamics 17

- Track/Train Dynamics, CN Rail — Phase VIII 19
- Track/Train Dynamics, CP Ltd. — Phase V 20
- Evaluation of Articulated Freight Car Trucks 21
- In-Service Radial Axle Truck Evaluation 22
- Economic Analysis of Rail Wear 23
- Development of a Rail Wear and Fatigue Model 24

Railway Equipment 25

- Tank Car Safety 27
- A.C. Traction Motors for Locomotives 28
- Microprocessor Control of Locomotive Propulsion Electronics 29
- Stirling Cycle Locomotive Engine 31
- Medium-Speed Diesel Combustion Research 33
- Shunter Locomotive Study 34

Railway Infrastructure 35

- Intermodal Terminal Operations Simulation 36
- Modular Railway/Highway Grade Separation Structures 37
- Rail Grinding Optimization 38
- Dynamic Controlled-Climate Test Facility 39
- New Railway Track Switch 41
- Study of Austenitic Manganese Steels for Railways 42

Signalling, Communications and Control 43

- Radio-Linked Train Location, Identification and Control (LIC) System — Operational Demonstration 45
- Study of LIC Application on Mainline Track 46
- Automatic Rail Car Identification System 47
- Field Test of Inductive Trainline Connector 49
- Train Data Recording System 50
- Control of Long Freight Trains 51
- Locomotive Speedometer Evaluation 52
- On-Board Hotbox Detection System 53
- Cab Information Display for High Ambient Light Conditions 54

Contents (cont'd)

Railway Passenger Projects 55
- Ride Monitoring System for Rail Vehicles 57
- Instrumentation of Wheelsets 58

Surface Technology 59

Intercity Road Technology 61
- Articulated Intercity Bus Testing and Evaluation 62
- Intercity Bus Fuel Efficiency 63
- Efficient Use of Bituminous Cement for Canadian Highways 64
- Highway Pavement Strength Testing Vehicle 65
- Compliant Air Bearings to Assist Intermodal Cargo Transfer 66

Innovative Urban Transit Technology 67
- Lightweight Bogie for Intermediate Capacity Transit Systems 68
- Development of a Commercial Frequency Linear Induction Motor 69
- Feasibility Study of an Intermodal Shuttle Service 71
- Non-Petroleum Energy Sources for Urban Transit 72
- SSTOP Program Enhancements 73
- Innovative Paratransit Vehicle Development 74

Tracked Levitated Vehicle Technology 75
- Maglev Development Program 77
- Assessment of Tracked Levitated Vehicles 78

Off-Road Vehicles 79
- Arctic Snowmobile Technical Study 80
- Vehicular Movement Over Ice Roads on Lakes and Rivers 81
- Aerobac Design Study 82

Alternative Energy Sources 83
- Development of Propane-Fueled Vehicles 84
- Optimization of Propane Engines 85
- Propane/Diesel Engine Development 86
- Hybrid Road Vehicle Development 87
- Diesel/Flywheel Hybrid Drive Train 88
- DISC Engine Feasibility Study 89
- Nickel-Zinc Batteries for Road Vehicle Propulsion 90
- Vehicle Battery Research and Development in Canada 91
- Advanced Battery Charger for Electric Vehicles 92

Transportation for the Mobility Handicapped 93
- Multimodal Wheelchair Securement/Passenger Restraint System 95
- Barrier-Free Terminals and Transfer Facilities 96
- Quick-Release Hand Controls for Automobiles 97
- Protective Containers for Wheelchairs 99
- Wheelchair Access System for Intercity Buses 100

Contents (cont'd)

- Communication Aids for Travellers with Sight, Speech or Hearing Impairments 101
- Computer Model for Scheduling and Routing of Special Public Transit Services 102

Air Technology 103

Energy Conservation 105

- Mixed Flow Turbine Study 106
- Fuel Efficient STOL Aircraft 107
- Small Transport Aircraft Fuel Efficiency 108
- Augmentor Wing Cruise Performance Study 109
- Gas Turbine Ceramics Technology 110

Air Safety and Systems 111

- Crashworthiness of Light Aircraft Structures 112
- Sonic Boom Research — Phase III 113
- Light Bulb Filament Impact Dynamics 115
- Toronto International Airport Intra-Airport Transportation Study 117
- Airport Application of ICTS: Feasibility Study 118
- Canadian Floating Offshore Air Terminal 119
- Transport Systems Safety Research 120

Communications and Control 121

- Doppler Radio Direction Finder — Operational Evaluation 123
- Aircraft On-Board Weight Sensor 125
- Unattended Navigation and Communications Facility (UNAVCOM) 126

Marine Technology 127

Arctic Vessel Research 129

- M.V. *Arctic* Scientific Evaluation Program 130
- Propeller/Ice Interaction Model Tests 132
- Finite Element Modelling of Propeller/Ice Interaction 133
- Protection of Propellers in Ice 135
- Semi-Empirical Ice Resistance Model 136
- Arctic Ships' Heat Flow Model 137
- Ice-Induced Hull Vibration 139
- Steering System Ice Loads, USCGC *Polar Star* 1982 Arctic Voyage 140
- Ship Manoeuvring Simulation Development 141
- Ballast Systems for Ice Navigation 142

Icebreaking and Ice-Related Research 143

- Air Cushion Icebreaking Bow Evaluation Program 144
- Analysis of Dynamic Icebreaking by Air Cushion Vehicles 145
- Integral Fluid Cushion Icebreaking Bow 146
- Air Cushion Technology Research 147
- SSACV Icebreaking LNG Tanker Feasibility Study 148

Contents (cont'd)

- Remote Sea Ice Thickness Sensor Development 149
- Ice Hazard Detection 150

Marine Transportation Systems 151

- Demonstration of Harbour Ice Management Techniques 153
- Ice Control for Arctic Ports and Harbours 154
- Archimedean Screw Tractor Evaluation 155
- Concrete Paving Blocks for Marine Terminals 156
- Engine Health Monitoring System 157
- Hydrostatic Stern Tube Bearing 158
- Development of a Low Resistance Barge 159
- Underwater Inspection System Development 160
- Quasi-Doppler Marine VHF Radio Direction Finder 161
- Wave Climate Study 162

Report Listing 16

Introduction

Transport Canada's **Transportation Development Centre**, TDC, has become the focus for the application of science and technology to improve transportation in this country. Formed in 1970, it is located in Montreal, the traditional headquarters for Canada's major transportation operators and equipment manufacturers.

TDC Role and Mission

TDC's role is to identify, promote and manage the application of science and technology towards a more efficient and effective Canadian transportation system.

Its mission is two-fold:

- to provide components of Transport Canada with specific data, research, and demonstration projects to assist them in their operational, regulatory, policy planning and evaluation functions.
- to undertake exploratory research and development addressing requirements in transportation technology and systems that are high risk, long range and national in scope.

TDC Approach

The research and development (R&D) undertaken by TDC responds not only to Transport Canada's mandate, but also to the needs of the transportation community. Close liaison is maintained with industry through modal advisory boards, which serve as valuable forums for information exchange. Liaison on transportation R&D activities is also maintained with foreign governments through "memoranda of understanding" on topics of common interest. Agreements are currently in place with the United States, Japan, West Germany and France.

TDC has a staff of multidisciplined professionals fulfilling the roles of researchers, program coordinators and project managers.

TDC is divided into two branches, the Program Development Branch and the Program Management Branch.

The Program Development Branch is concerned with the forward-looking, planning and activity development aspects of TDC. It is TDC's intelligence focal point regarding the trends, needs and opportunities for R&D both Canadian and worldwide.

The Program Management Branch is responsible for the implementation and management of TDC's R&D projects. This branch's work is partitioned among three divisions:

- Current Technology Division
- Advanced Technology Division
- Technology Applications Division

Current Technology projects are concerned with R&D aimed at improving or modifying conventional transportation technology. These projects involve developing prototypes, conducting test programs and documenting the results in reports. Follow-on work for current technology development frequently takes the form of in-service evaluation by transport operators.

Advanced Technology projects investigate new concepts and innovative technical solutions that have promise for overcoming shortfalls in systems using conventional technology. Developments resulting from these projects are often necessarily supported by quantitative assessments of the economics and user acceptability of the technology.

Technology Applications projects involve application testing and evaluation of technological developments, including the systems analysis studies needed to establish a base for assessment and comparison. Technology demonstration projects are directed towards introducing, on an experimental basis, new methods, equipment and systems.

Program Funding

In carrying out its mission, TDC commissions and funds R&D activities performed by organizations in the private sector. These funds come not only from TDC's budget but also from other components of the federal government that choose to make use of TDC's infrastructure for project management.

Other government departments that provide funds are Department of Supply and Services (DSS), National Research Council (NRC), Energy, Mines and Resources (EMR) and its Energy R&D Panel, and Industry, Trade and Commerce (IT&C). In addition, in the current fiscal year, the Ministry of State for Economic and Regional Development has approved augmented funds for research projects relating to rail freight and Arctic marine technologies. These funds are identified in the directory as TDC-RF and CMTA-AM, respectively. Funds are also provided from Transport Canada's operating administrations: the Canadian Air Transportation Administration (CATA), the Canadian Marine Transportation Administratio (CMTA) and the Canadian Surface Transportation Administration (CSTA)

The funding represents the value of active contracts, and not necessarily the total expenditure on a project. Financing of multiphase projects for example, is normally arranged phase by phase, with the results of completed phases used as a basis for the definition of subsequent phas

TDC Publications

Project Directory

The Project Directory is published annually to disseminate information on TDC's R&D activities to the transportation community. The directory is organized according to the principal thrust areas of TDC's research and development program in transportation technologies: rail, surface, air and marine.

Each project description briefly relates the rationale for the work, its objective, and the methodology for the achievement of these objectives. Also given are an account of completed work, the name of the performing organization, and titles of reports.

The project description is accompanied by supplementary information consisting of the work schedule, project and file numbers and funding from all sources. For further information on a project, readers are invited to contact the TDC officer named in the project description.

Research Reports

The product of each TDC project is a technical report. The Report Listing on page 163 contains the titles of all TDC publications available to the public on request while supplies last. Reports may also be borrowed through interlibrary loan from the TDC library in Montreal or from the Transport Canada Library and Information Centre, Transport Canada Building, 2nd floor, Ottawa, Ontario K1A 0N5. The Transport Canada Library and Information Centre provides paper copies of reports at a charge of 20¢ per page.

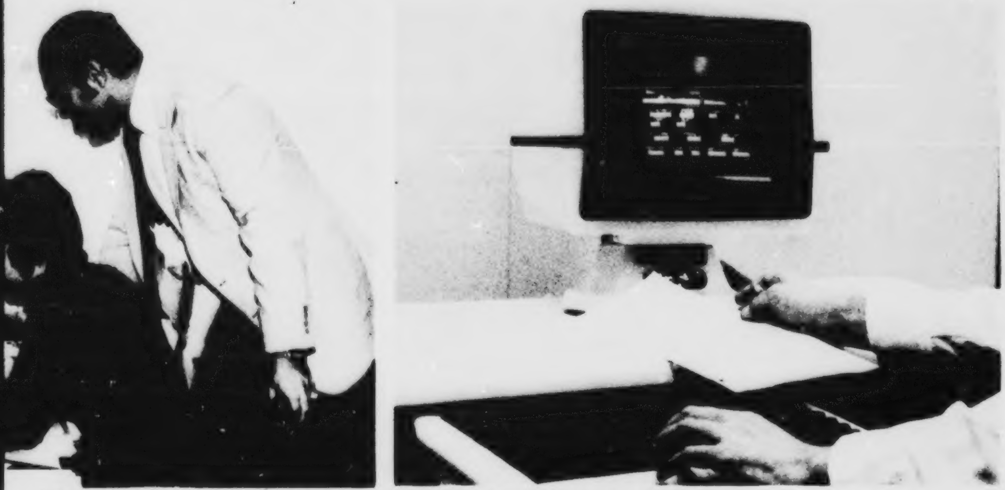
Out-of-print reports dated 1979 and onwards are available on microfiche for $5.00 from Micromedia Ltd., 144 Front Street West, Toronto, Ontario M5J 1G2. Out-of-print reports dated 1971 to 1978 are available on microfiche for $2.50 from the Library and Information Centre in Ottawa.

TDC at a glance...

Established in 1971 to support TDC projects, **the library** boasts a highly specialized transportation collection of more than 10,000 catalogued books and reports, plus 4,500 additional reports on microfiche, covering many aspects of all modes of transportation. The library also subscribes to almost 500 periodicals, magazines and newsletters and to the Statistics Canada Publication Series.

With the adoption of the University of Toronto Library Automation System (UTLAS), the TDC library joined a growing community of scientific and technical libraries using computer-based information systems.

TDC maintains a creative **publications section** to provide design input for a variety of publications, audio-visual displays, keynote magazine articles, TDC's Annual Report and other types of information presentations. The Project Directory is one example of its work.

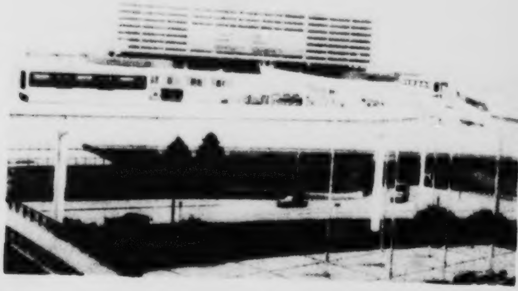


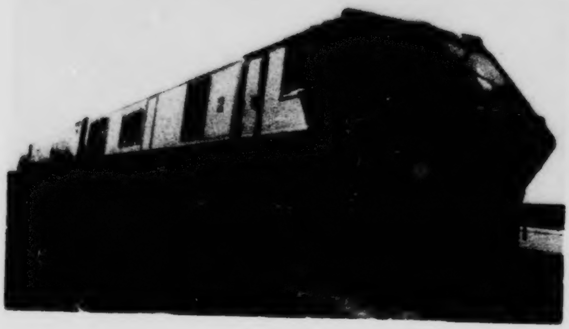
Management and control of the Centre's financial activities are performed by the **finance and MIS section**, with the help of its time-shared, computer-based Management Information System. TDC uses its own mini-computer to enable most efficient use of the MIS.

TDC reports are retained in the **report depository** and are available on request while supplies last.

TDC project officers keep abreast of transportation developments through weekly presentations of current project work.

Multimodal Purview of TDC





Railway Technology

Railway Electrification 9

Track/Train Dynamics 17

Railway Equipment 25

Railway Infrastructure 35

Signalling, Communications and Control 43

Railway Passenger Projects 55

Railway Electrification

A 1976 study by the Canadian Institute of Guided Ground Transport has shown that substantial benefits are to be gained by electrification of Canadian mainline track. The study recommended a prototype operation on mainline track as a first step in the electrification process. With a 1976 cost of $229 million, this was considered to be impractical.

In 1981, an opportunity arose for electrification of railway lines in one of two locations, a 20 km section of the Cartier Railway Company line in Quebec or a 132 km section of the new Tumbler Ridge branch line of BC Rail in British Columbia. The Tumbler Ridge branch line was recently selected as the site for the electrification demonstration project, to be jointly sponsored by BC Rail and the provincial and federal governments.

The demonstration will permit the evaluation of the feasibility of electrification as a propulsion energy alternative for rail transportation. As a testing ground for various technologies, generating data on costs, construction standards and procedures, the demonstration will provide firsthand operating experience with electrification technology under Canadian conditions.

The projects in this section reflect the multi-disciplinary involvement required to mount an effective rail electrification demonstration. They include:

Cartier Railway Electrification Demonstration Study, which provided design and cost estimates for a demonstration;

BC Rail Electrification Study, which transfers the experience to date of the CRC demonstration work to a mainline engineering feasibility study, including the electrification of steep grades and tunnel segments of track;

Standards Study for Railway Electrification, the definition of common standards involving several railway, utility and supplier companies;

Power Supply Factors in Railway Electrification, research to determine optimum voltage and frequency for the power distribution system necessary for electrification;

Signal System Design for Electrified Section of Cartier Railway, the detailed design of a signalling system for the CRC demonstration;

Energy Storage System for Railway Electrification, study of a system for temporary wayside storage of energy produced by trains braking on downgrades for reuse by trains requiring extra power for negotiating upgrades;

Catenary Mast Tests, testing of several low-cost catenary masts for the electrified rail line.

Cartier Railway Electrification Demonstration Study

Description

The objective of this project is to provide a design and cost estimate of a railway electrification demonstration that can be used to evaluate the feasibility of electrification and its effectiveness in a typical severe Canadian environment. Electrification of Canadian railways has been considered many times, but the high costs make thorough testing essential before commitment to a major electrification scheme. Until now no practical test site has been available to demonstrate and evaluate railway electrification technology in Canada.

In 1976, the Canadian Institute of Guided Ground Transport (CIGGT) completed a study of rail electrification that recommended a Canadian demonstration. The demonstration involved electrification of 1360 km of track at an estimated cost of 229 million (1975) dollars. This sum was considered impractical.

In 1980, in light of the rising costs of petroleum-based energy, CIGGT carried out an update of its study and electrification looked more beneficial than it did in 1976. A demonstration was again recommended, but there appeared to be no ready means of achieving it with either CN Rail or CP Rail.

The same year TDC completed a study into the application of wayside energy storage systems to Canadian railways and concluded that the Cartier Railway Company (CRC) would benefit from the use of dual-mode locomotives and from wayside flywheel energy storage. CRC concurred and, as electrification is a prerequisite to the use of wayside energy storage, agreed to examine the electrical power, engineering and construction requirements of an electrification demonstration.

For this project, investigators carried out a detailed engineering definition study for an electrification demonstration of a pusher locomotive operation on CRC's main line between Lac Jeannine and South Tup siding, looking at power supply and transmission, substations, overhead power supply, locomotives and signalling.

Progress to May 1982

This project is complete.

Contractors

Quebec Cartier Mining Co., Port Cartier, Quebec
Canadian Pacific Consulting Services Ltd., Montreal, Quebec

Reports

TP 3611E, Engineering Study for an Electrification Demonstration Project with the Cartier Railway Company, summary report, Canadian Pacific Consulting Services Ltd., March 1982.

TP 3525, Engineering Study for an Electrification Demonstration Project with the Cartier Railway Company, final report, Canadian Pacific Consulting Services Ltd., April 1982.

TP 2961, Quebec Cartier Mining Company Engineering Definition Study for an Electrification Demonstration, Field Survey Report, Canadian Pacific Consulting Services Ltd., March 1981.

Schedule: May 1981 — January 1982
Funding: TDC-RF — $198,700
Energy R&D Panel — $ 50,000

Project Number: 4260, 4267
File Number: D-1465-317-2
Project Officer: C.A. Versailles

BC Rail Electrification Study

Description

The objective of this project is to conduct an engineering feasibility study of the electrification of steep grade and tunnel segments for the planned Tumbler Ridge branch line of BC Rail.

BC Rail is constructing the 132 km rail line to service the coal mine developments in northeast British Columbia. The proposed line will have two tunnels, 5 km and 9 km, as well as significant gradients along the route. Diesel-electric motive power was originally planned, but electrification would provide an attractive alternative.

This project will investigate the feasibility and probable costs of electrifying segments of this planned rail line. It will make extensive use of the cost data obtained for the Cartier Railway Company electrification demonstration.

The results of this work will define the technical problems and the costs and benefits of railway electrification.

Progress to May 1982

This project is complete. The findings show that electrification is a feasible alternative for BC Rail's Tumbler Ridge branch line and would offer substantial savings by eliminating the need for tunnel ventilation. BC Rail has decided to electrify this section and Transport Canada to use it as a demonstration test site. Canadian Pacific Consulting Services Ltd. has been named as the prime consultant for the demonstration project.

Contractor

British Columbia Railway, Vancouver, British Columbia

Report

TP 3619, Electrification Study for British Columbia Railway Tumbler Ridge Branch Line, Canadian Pacific Consulting Services Ltd. and CANAC Consultants Ltd., April 1982.

Wolverine tunnel of the Tumbler Ridge branch line

Schedule: February 1982 — April 1982
Funding: TDC-RF — $30,000

Project Number: 4587
File Number: D-1465-317-7
Project Officer: C.A. Versailles

Standards Study for Railway Electrification

Description

National railway electrification in Canada would involve several railway, utility and supplier companies. In order to fully achieve the potential benefits of railway electrification, safety, design, construction, operation and maintenance standards must be developed before any major railway electrification undertaking took place.

The objective of this project is to provide documented findings and suggest recommendations on standards that can be applied to railway electrification in Canada.

Technical literature will be searched and findings assembled on codes, standards and procedures dealing with specific subjects on railway electrification. The assembled data will be analyzed and synthesized to produce a rationalized list of standards that can be considered in the Canadian context.

A section of the study will be devoted to the design and cost estimates of a catenary mast constructed from salvage rail. The suitability of such a mast will be evaluated as an alternative to conventional steel or wood structures.

The study recommendations will be applied to the pilot demonstration of railway electrification.

Progress to May 1982

A large amount of pertinent literature on the subject has been identified. The Canadian Institute of Guided Ground Transport is assisting the contractor by classifying the collected material prior to its assessment.

Contractor

Canadian Pacific Consulting Services Ltd., Montreal, Quebec

Report

None to date

European electric locomotive cab

Schedule: March 1981 — December 1982
Funding: TDC — $15,000

Project Number: 4523
File Number: D-1465-317-4
Project Officer: C.A. Versailles

Power Supply Factors in Railway Electrification

Description

This project is part of TDC's railway electrification program and, more specifically, is related to the Canadian Railway Electrification Study carried out by the Canadian Institute of Guided Ground Transport (CIGGT) in 1976 and updated in 1980. It expands on the CIGGT study by looking at alternatives to the originally selected 50 kV, 60 Hz overhead catenary, energy power distribution system.

Researchers evaluated a 25 kV, 60 Hz distribution system with a single-phase tap and with a three-phase tap; a 25 kV, 20 Hz system with both single and three-phase taps; and a high voltage d.c. system.

Researchers expect to gain a better understanding of the technical difficulties and the probable costs and benefits of power distribution alternatives for railway electrification in the Canadian context.

Progress to May 1982

This project is complete. Findings indicate that high voltage such as 50 kV is the most acceptable for widespread Canadian operation. Given the considerable savings demonstrated by 50 kV over 25 kV, it was recommended that the technical limitations to railway voltages in excess of 50 kV be further studied.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

TP 3526, Power Distribution Alternatives in Canadian Railway Electrification, Queen's University, Canadian Institute of Guided Ground Transport, 1982.

A 15 kV, 16-2/3 Hz distribution system is used in Sweden's electrified rail system

---

Schedule: May 1981 — March 1982
Funding: Energy R&D Panel — $50,000
Project Number: 4326
File Number: D-1455-337
Project Officer: C.A. Versailles

Signal System Design for Electrified Section of Cartier Railway

Description

The objective of this project is to provide a detailed signal system design for the proposed Cartier Railway Company electrification demonstration.

In the engineering definition study for the demonstration, researchers prepared several alternative designs of track circuits capable of interfacing with existing equipment without major change. The study recommended the combination of these alternatives in one system, using each to its greatest advantage.

To achieve this, work in the current project will include:

- a detailed design of a signal system incorporating a phase selective circuit, a model TRU-11 circuit and single rail d.c. circuits, using existing hardware that is readily adaptable and compatible with a 25 kV, 60 Hz railway electrification system; and,
- preparation of track circuit schematics, including impedance bonding and insulation track joints, with comprehensive description of installation requirements.

The result of this effort should be a least-cost system design applicable across Canada.

Progress to May 1982

The signal system has been designed and the schematics and installation directions are being prepared.

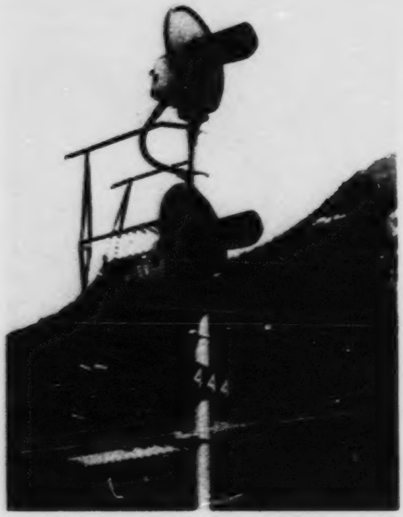
Contractor

Canadian Pacific Consulting Services Ltd., Montreal, Quebec

Report

None to date

Typical railway signal currently in use



Schedule: February 1982 — May 1982
Funding: TDC-RF — $15,000

Project Number: 4585
File Number: D-1465-317-5
Project Officer: C.A. Versailles

Energy Storage System for Railway Electrification

Description

The objective of this project is to undertake a concept definition study of developing technologies in temporary energy storage applicable to railway electrification, with emphasis on the development of a system applicable to the Cartier Railway Company electrification demonstration.

In recent years, TDC has sponsored projects to study temporary wayside energy storage by flywheels and superconductive coils. The stored energy is used for locomotive propulsion. Both methods were demonstrated to be feasible.

For the current project the contractor reviewed and collected technical and cost data and co-operated with the Cartier Railway Company to establish site-specific constraints.

Results of this work will permit the development of an energy storage system together with a definition of costs and implementation strategies.

Progress to May 1982

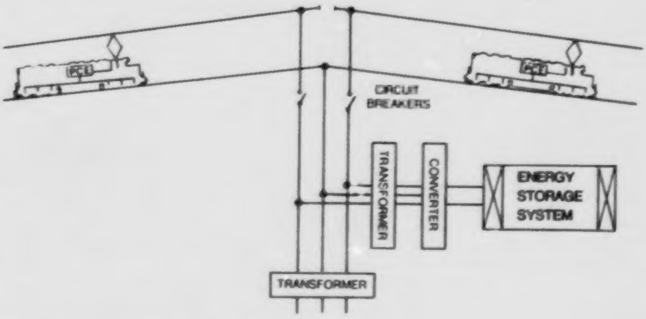
This project is complete. An assessment was made of pertinent technologies including design trends and development plans of equipment manufacturers. It was concluded that among the energy storage systems evaluated for near-term wayside systems, only two are considered to be economically practical, the lead-acid battery and the steel flywheel.

Contractor

SNC Inc., Montreal, Quebec

Reports

TP 3622E, Concept Definition of Wayside Energy Storage Systems (WESS) for Railway Electrification, SNC Inc., March 1982.
TP 3610E, Concept Definition of Wayside Energy Storage Systems (WESS) for Railway Electrification, summary report, SNC Inc., March 1982.



Schematic of regeneration system

Schedule: March 1981 — May 1982
Funding: TDC-RF — $47,000

Project Number: 4458
File Number: D-1465-355
Project Officer: C.A. Versailles

Catenary Mast Tests

Description

The objective of this project is to test four different types of low cost catenary mast as candidates for the railway electrification demonstration.

The detailed engineering study for the demonstration produced four alternative designs for a low cost catenary mast: a wooden mast, two configurations of masts fabricated from scrap rail, and a standard laced-steel mast.

For this project a non-energized catenary will be constructed and installed in a railway environment to evaluate each of the four alternatives in long-term exposure tests. A set of masts of each design will also be strain-gauged and structurally tested at the National Research Council's railway engineering laboratory.

The choice of masts can have an important effect on the cost of electrification; the results of this work could therefore produce major economic benefits.

Progress to May 1982

The four types of mast and their hardware have been purchased. The salvage rail configurations have been shipped to the National Research Council for testing.

Contractor

Canadian Pacific Consulting Services Ltd., Montreal, Quebec

Report

None to date

Laced-steel catenary mast used in Europe

Schedule: February 1982 — June 1982
Funding: TDC-RF — $30,000

Project Number: 4586
File Number: D-1465-317-6
Project Officer: C.A. Versailles

Track/Train Dynamics Research

An extensive and highly productive program of rail research in North America relates to track/train dynamics, the study of how a rolling train interacts dynamically with the track that supports and guides it.

Early in 1972 the Association of American Railroads (AAR) formulated a ten-year plan for the study of track/train dynamics. TDC collaborates with the AAR to coordinate the research carried out by Canadian and U.S. government agencies, independent associations and private companies.

The objectives of this program are to develop a better understanding of track/train dynamics so as to improve train handling; develop effective standards for track and equipment to cope with higher speeds and heavier trains, and redesign critical components of track structure, locomotives and rolling stock to meet the future needs of rail systems.

On-going projects in the Canadian program include:

Track/Train Dynamics Research, CN Rail and CP Rail: research aimed at a better understanding of the interaction between a moving train and the track.

Evaluation of Articulated Freight Car Trucks: evaluation of the DR-1 truck by CN Rail.

In-Service Radial Axle Truck Evaluation: testing of five types of radial truck.

Economic Analysis of Rail Wear: calculation of annual savings per car resulting from operations and equipment that reduce loads experienced during curving, with the attendant reduction in rail wear.

Development of a Rail Wear and Fatigue Model: establishment of a wear and fatigue theory that takes into account parameters influencing the wheel/rail system under three lubrication regimes.

Ballast testing by CN Rail

Test of rail fastener

Track/Train Dynamics, CN Rail — Phase VIII

Description

TDC's track/train dynamics program with CN Rail is aimed at better understanding the interaction between a moving train and its track, and using that understanding in the development, operation and maintenance of railway track and equipment.

The major accomplishments to date of this ten-year program include the development of an articulated freight car truck; the redesign of three-axle locomotive trucks so as to reduce lateral curving forces; the development and field testing of fully instrumented wheelsets for freight cars; the design of a new wheel profile to reduce rail and wheel wear; and, the accumulation of a useful body of data on concrete ties.

Work in the latest phase of the program was largely concerned with track structures, and included:

- laboratory and field evaluation of the second-generation CN 60B concrete tie;
- continuation of laboratory and field studies to determine a method of predicting subballast thickness requirements;
- laboratory tests to determine strength and stability of ballast materials; and,
- field measurement of longitudinal rail stress.

Progress to May 1982

Phase VIII is now complete. The CN 60B concrete tie, an improved version of the CN 60A tie, is being installed in track. Laboratory tests showed the CN 60B to be stronger than its predecessor. Collection of data for predicting the requirements for subballast thickness is continuing at two major test sites, Joliette, Quebec, and Edmonton, Alberta.

Modifications were made to the direct shear testing machine used for ballast shear tests. With these improvements the classification of the strength and stability of sample ballast materials was completed. Considerable effort is being directed towards finding a method to measure the longitudinal force in continuous welded rail and to control the heating of this rail during installation in track.

Contractor

Canadian National Railway, Montreal, Quebec

Reports

TP 3586, Track Structures Test Facility, test report no. 5: Measurement of Track Modulus, CN Rail, January 1982.
TP 3585, 1980 Laboratory Research on Concrete Ties, CN Rail, November 1981.
TP 3584, Track/Train Dynamics, Phase VIII, final report, CN Rail, March 1982.
TP 3346, Measurement of Concrete Tie Centre Bending Deflections, Albreda and Rivers Subdivisions — September 1980, CN Rail, September 1981.
TP 2987, Predicting Requirements for Subballast Thickness, progress report no. 2, CN Rail, April 1981.

Schedule: April 1981 — March 1982		**Project Number:** 4288
Funding: TDC —	$160,000	**File Number:** D-1465-106-6-8
CN Rail —	$160,000	**Project Officer:** D.W. Dibble

Track/Train Dynamics, CP Ltd. — Phase V

Description

TDC's track/train dynamics program with Canadian Pacific Limited is aimed at better understanding the interaction between a moving train and its track and using that understanding in the development, operation and maintenance of railway track and equipment.

Phase IV work included investigation of fatigue crack initiation and crack propagation in rail; development of a computerized method to measure wheel profile and of laboratory apparatus to study wheel and rail wear; investigation of the wear and fracture characteristics of two wheel profiles, effectiveness of new grease compounds in reducing wear in curves, and the nature and magnitude of rail wear under heavy traffic conditions; and, evaluation of the performance of freight and locomotive trucks.

Phase V work includes development of a second-generation wheel profilometer to measure wear; field tests to collect lateral force and angle of attack data on in-service freight train locomotives so as to provide the load spectrum on track and identify the distribution of angle of attack; continuation of analytical work to study wheel/rail and wheel/roller quasi-static and dynamic systems; and, collection and monitoring of rail profile measurements using a rail profilometer.

Progress to May 1982

A concept for an improved wheel profile measuring head has been developed. It is being incorporated into a system for automatic measurement and processing of wheel profile data.

Field tests were conducted with modified SD40-2 locomotive trucks to obtain wheel/rail force and angle of attack data to correlate with computer results from an analytical model.

A rail profilometer, developed by CP Ltd., has been modified to simplify the measuring process. Calibration of the profilometer is now underway and field tests will follow.

Contractor

Canadian Pacific Limited, Montreal, Quebec

Reports

TP 3503, Concept of a Profilometer for Rail Wear Determination, CP Ltd., December 1981.

TP 3449, Theoretical Curving Performance of Four Freight Car Trucks, CP Ltd., December 1981.

Profilometer measuring rail profile

Schedule: May 1981 — December 1982
Funding: TDC — $203,000
CP Ltd. — $203,000

Project Number: 4269
File Number: D-1465-106-7-4
Project Officer: D.W. Dibble

Evaluation of Articulated Freight Car Trucks

Description

The DR-1 articulated truck being tested by Canadian National Railway under the track/train dynamics program has the potential to provide significant economic benefits in rail operations. The DR-1 truck is effective in reducing lateral curving forces and angle of attack, while maintaining stability at high operating speeds. Angle of attack is an indication of the position of the wheel on the rail and thus of the amount of contact area between the rail and the wheel, which is a main factor in the wear process of both rail and wheel.

The objective of this project is to provide the railway industry with quantitative data on the benefits of the DR-1 truck by evaluating the following factors in the operation of a 100-car unit train equipped with DR-1's:

- reduced rolling resistance and its effects on train handling procedures;
- reduced rolling resistance on curved track and its effects on fuel consumption;
- wheel wear for conventional and articulated trucks; and,
- relative rate of replacement of components of conventional and articulated trucks.

Progress to May 1982

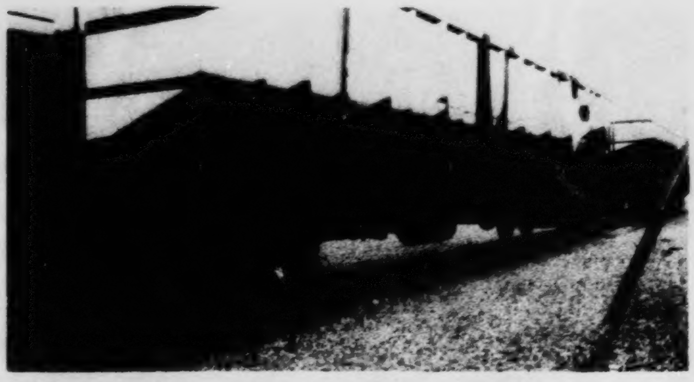
The assembly of a full unit train has not yet been achieved, although all the necessary instrumentation has been acquired. However, some 100 cars equipped with DR-1 trucks have operated in Alberta and British Columbia for three years in a wheel/rail monitoring program with several standard trucks. Logging about 300,000 km, the DR-1 trucks performed well.

Contractor

Canadian National Railway, Montreal, Quebec

Report

None to date



DR-1 articulated truck on CN coal hopper car

Schedule: March 1981 — March 1983

Funding: TDC —	$100,000
Energy R&D Panel —	$142,000
CN Rail—	$242,000
Total —	$484,000

Project Number: 8957, 8958
File Number: D-1465-108-10
Project Officer: D.W. Dibble

In-Service Radial Axle Truck Evaluation

Description

In 1978, Canadian Pacific Limited conducted a test program to obtain quantitative data on the performance of five radial truck designs: Barber Scheffel, Dresser DR-1, Devine Scales, National Swing Motion and Ride Control. Of these, the Barber Scheffel and the DR-1 trucks were the most effective in reducing lateral curving forces and angle of attack while maintaining stability at high operating speeds.

Angle of attack is an indication of the wheel position on the rail and thus of the amount of contact between the rail and the wheel, which is a main factor in the wear process of both rail and wheel. The assessment of the performance of the DR-1 truck in revenue service could not be undertaken immediately because the Wabcopac truck-mounted brake system, used on CP trucks, was incompatible with the DR-1 design. The incompatibility problems have now been overcome through design modifications to the DR-1 truck. The modified DR-1 truck is called DR-2.

In the current project, researchers will test in unit coal train service a minimum of five test cars each of the Barber Scheffel truck, the DR-2 truck and the conventional Barber S-2 truck. The test cars will be equipped with the modified Heumann profile wheels. Wheel profile will be measured with a specially designed profilometer. The results of these tests will give CP quantitative data on which to base a preliminary evaluation of these trucks for its operations.

Progress to May 1982

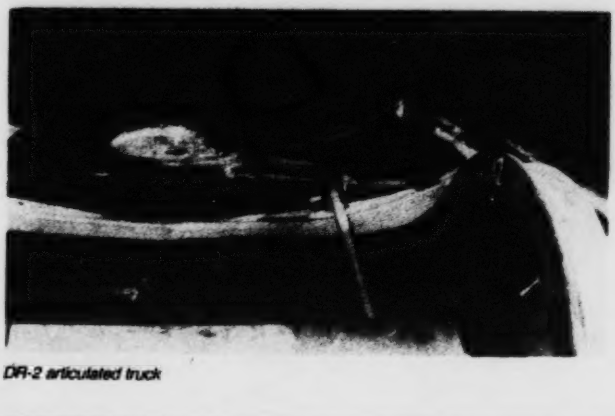
Five carsets of Barber Scheffel trucks have been installed on 100-ton bathtub coal cars. Three similar cars equipped with standard trucks are being used for baseline comparison. The DR-2 truck operation is expected to start in the summer of 1982.

Contractor

Canadian Pacific Limited, Montreal, Quebec

Report

None to date



DR-2 articulated truck

Schedule: August 1981 — January 1983
Funding: TDC — $111,000
CP Ltd. — $111,000

Project Number: 4257
File Number: D-1465-106-11
Project Officer: D.W. Dibble

Economic Analysis of Rail Wear

Description

Part of a joint TDC/U.S. Federal Railroad Administration (FRA) research program, this project involves the study of freight car trucks as they affect rail wear. The Canadian Institute of Guided Ground Transport (CIGGT) has developed analytical models that predict rail wear by trucks. Over the last few years, CIGGT has been developing a comprehensive computer model that provides a detailed, accurate trace of the passage of a wheel, the generation of an increment of rail wear and the subsequent generation of an incremental rail renewal cost.

The CIGGT estimates are developed in terms of cost savings from a reduction in vertical and lateral loads during curving. Savings per unit of track in several curvature categories are taken into account, as are estimated savings from rail, ties and other track costs. These estimated savings are converted into annual savings per car. Economic analysis of rail wear was carried out so as to provide costs applicable to both U.S. and Canadian situations.

Data from the FRA's Truck Design Optimization Project on lateral and vertical forces and angle of attack were provided to CIGGT by Wyle Laboratories of Colorado for five Type II freight car truck configurations: Barber Scheffel, Dresser DR-1, National Swing Motion, Devine Scales and Maxiride. The vehicle and track parameters and dynamic performance measurements necessary for running the wear portion of the rail wear cost model were also provided.

Progress to May 1982

CIGGT established the economic parameters to be used in the costing routine and developed computer subroutines for the reduction of the data. The results of the program will be provided to Canadian railways.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

Draft, Rail Wear Economic Analysis for Truck Design Optimization Project, Canadian Institute of Guided Ground Transport.

Schedule: January 1980 — September 1982
Funding: TDC — \$46,000

Project Number: 4070
File Number: D-1450-110-5-5
Project Officer: D.W. Dibble

Development of a Rail Wear and Fatigue Model

Description

Railway researchers have recently been focusing their attention on means to increase the operational life of rail and, in particular, on the wear and fatigue phenomena in the wheel/rail system. Their concern can be attributed to the unprecedented increase in rail wear and fatigue resulting from the introduction of heavily loaded cars on mainline railways. Rail wear and fatigue has been a subject of wide research, although most studies have only treated selected parameters in isolation.

The purpose of this project is to establish a unified rail wear and fatigue theory that takes into consideration the parameters influencing the wheel/rail system under different lubrication regimes. Three sets of interrelated parameters, mechanical, metallurgical and rheological, will be considered.

This is a joint project of the Association of American Railroads and TDC, being conducted by the National Research Council's Western Laboratory and by the University of Rhode Island. The first phase of the project will concentrate on the investigation of rolling contact fatigue and adhesive wear that takes place on rail in a dry regime, that is, no lubrication.

Field experimental data and data generated on the NRC's wheel/rail wear apparatus and on systems at the mechanical engineering laboratory of the University of Rhode Island will be used to validate the rail wear and fatigue model. The laboratory work will investigate surface and subsurface characteristics of worn and fatigued rail material selected from mainline track with known histories. This will be supplemented by analysis of rail disc specimens, which will be subjected to controlled combinations of mechanical, metallurgical and rheological parameters.

If the first phase results are satisfactory, a second and third phase will be undertaken to investigate lubrication and intermittent lubrication regimes.

A unified rail wear and fatigue theory would be a valuable tool for the prediction of rail life, wear and fatigue.

Progress to May 1982

Several wheel discs from two different rail metallurgies have been obtained and are now running on the test-rig. Two different loads and six angle of attack settings are being used.

Contractor

National Research Council, Ottawa, Ontario

Report

None to date

Schedule: November 1981 — November 1982
Funding: TDC-RF — \$46,400
NRC — \$60,000

Project Number: 4522
File Number: D-1465-366
Project Officer: D.W. Dibble

Railway Equipment

Improved equipment benefits all users of the Canadian railway system by offering greater safety, reliability and operating efficiencies. Current equipment-related projects are:

Tank Car Safety: research aimed at improving the safe transportation of dangerous goods in tank cars.

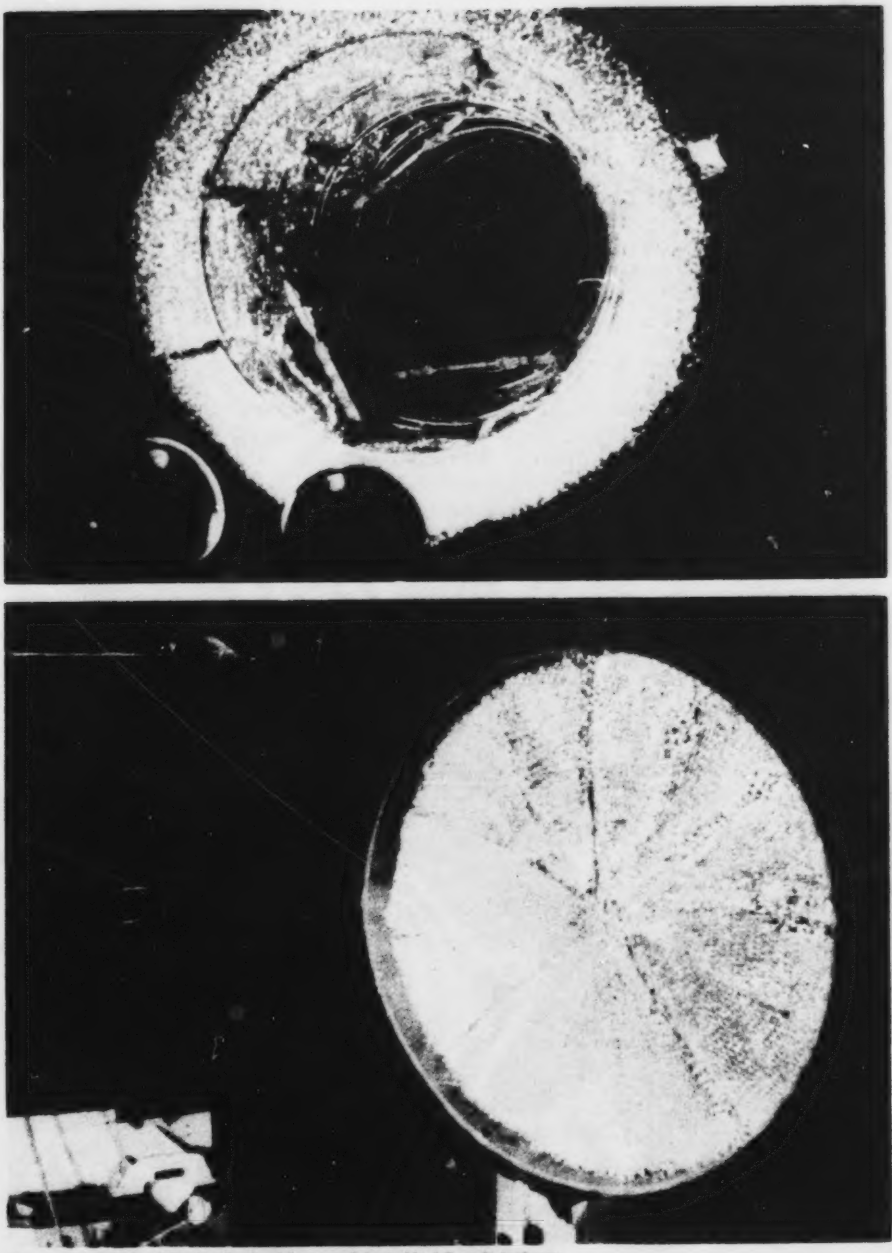
A.C. Traction Motors for Locomotives: these robust motors have the potential to improve the traction capability of locomotives.

Microprocessor Control of Locomotive Propulsion Electronics: development of a microprocessor-based power control unit for an a.c.-d.c.-a.c. diesel/electric freight locomotive.

Stirling Cycle Locomotive Engine: the development of a small-scale Ringbom-Stirling cycle engine as a preliminary step to the development of a full-scale locomotive engine.

Medium-Speed Diesel Combustion Research: the study of the effects of changes in specifications of combustion fuels on engine efficiency.

Shunter Locomotive Study: research aimed at developing a modern, fuel-efficient shunter locomotive.



Two configurations of Explosafe aluminium mesh tested in 1:5 scale tank car

Tank Car Safety

Description

Transport Canada is in the process of establishing regulatory requirements for the safe transport of dangerous goods.

In the transportation of liquid petroleum gas (LPG) and propane, minor accidents can sometimes lead to boiling liquid expanding vapour explosions or "BLEVE's". (There is some controversy over the use of the term BLEVE; here it is used to denote the result of a thermally induced rupture of a pressurized LPG or propane container.) These ruptures can be the result of the spilling and subsequent ignition of inflammable liquids such as gasoline, or the blow-torch effects of a flame issuing from punctured tank cars after derailment.

The hazard of a BLEVE may be reduced by shielding the cargo tank so as to prolong the time between the beginning of the external heat impingement and the occurrence of the BLEVE. This time delay would not only permit the safe evacuation of the immediate surroundings, but would also provide time for the fire fighting crew and equipment to take appropriate measures.

A method for reducing the risk of a BLEVE developed by the Canadian firm Vulcan Industrial Packaging Limited and known as the Explosafe system was successfully demonstrated in 1:5 scale tests conducted in a previous TDC-sponsored project. Using conductive aluminium mesh as an interior tank lining, the system is designed to conduct heat away from the point of application and diffuse it throughout the cargo liquid. This prevents the build-up of a hot spot that can weaken the structure of the tank and cause it to fail under the pressure of the expanding liquid.

As a result of the positive findings from the previous Explosafe testing, TDC is sponsoring further work in this field. This work includes:

- computer modelling of the heat transfer process in rail tank cars. The model will be validated using, in part, the results of the earlier tests. The model will be used to analyze various design configurations of the aluminium mesh within a full-scale car;
- engineering design of a tank car containment system; and,
- tests of the Explosafe system in full-scale tank cars.

Progress to May 1982

Two contractors are involved in developing mathematical models as the first phase of the thermal modelling project. These models, when completed, will be evaluated and one selected for development into the computer model.

Contractors

Davis Engineering Ltd., Ottawa, Ontario
H.G. Engineering Ltd., Don Mills, Ontario

Report

None to date

Schedule: January 1982 — September 1982
Funding: TDC-RF — $73,000

Project Number: 4468, 4559
File Number: D-1465-302-6
Project Officers: L.A. McCoomb, D.W. Dibble

A.C. Traction Motors for Locomotives

Description

TDC has been supporting studies and research into alternating current (a.c.) propulsion for transportation since 1971. This work has identified the North American railway locomotive as a promising application for a.c. traction motors.

The a.c. motor is lighter and more robust than the d.c. motor and would also alleviate the problem of snow and moisture ingestion around the commutator, a condition that currently accounts for some 30 per cent of the yearly failure rate of traction motors. While requiring the same amount of space as the lower horsepower d.c. motor, it is expected to allow a higher power/axle ratio for locomotives.

The development of a.c. traction for railway locomotives is well advanced in Europe with operational evaluation underway in six countries. Because of the different operating requirements and environmental conditions in North America, the European a.c. propulsion technology is not directly transferable to Canada.

The objective of this project was to define a standardized three-phase a.c. locomotive traction motor suitable for North American railway conditions and practices.

Progress to May 1982

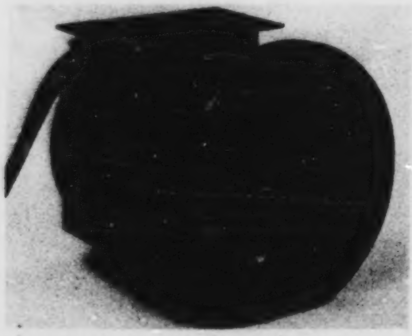
This project is complete. Researchers used applicable information from the European research to assist in the definition of a single standardized a.c. traction motor capable of being used with existing and planned locomotives from a variety of North American locomotive manufacturers. A 1000 horsepower motor was defined as being the most suitable for North American needs. Industry, Trade and Commerce Canada, Brown Boveri Canada Ltd., Bombardier Inc. and CP Rail have negotiated a project for the testing of such a motor in a CP Rail locomotive.

Contractor

Brown Boveri Canada Ltd., Pointe Claire, Quebec

Report

TP 3388, A.C. Traction Motors for Locomotives, Brown Boveri Canada Ltd., May 1982.



Brown Boveri's a.c. traction motor

Schedule: May 1980 — December 1981		**Project Number:** 4205
Funding: TDC —	$15,000	**File Number:** D-1465-316
Brown Boveri Canada Ltd. —	$15,000	**Project Officer:** M. Audette

Microprocessor Control of Locomotive Propulsion Electronics

Description

In the on-going development of an a.c. propulsion package for diesel-electric freight locomotives, there remain several problems requiring specific research. One of these problems is a.c.-d.c.-a.c. control electronics. There cannot be a direct transfer of existing European technology in this area, chiefly because of the physical size of the equipment.

The objective of this project is to develop a microprocessor-based controller for an a.c.-d.c.-a.c. diesel-electric freight locomotive power control unit, and to test the propulsion electronics in operational service.

The flexibility of a microprocessor-based control system is not its only advantage; it also offers the benefits of reduced size, weight and cost of electronics. The microprocessor can be a major asset in handling hardware malfunctions and making accurate diagnoses for simpler maintenance procedures.

Successful completion of this project will significantly improve the attractiveness of a.c. propulsion for Canadian railways, and will accelerate its introduction into service.

Progress to May 1982

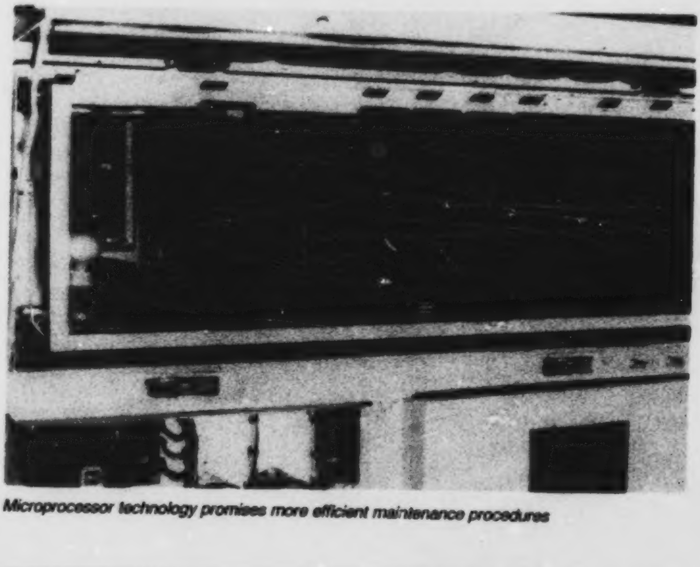
This project has just started.

Contractor

Brown Boveri TRM Industries Inc., Lachine, Quebec

Report

None to date

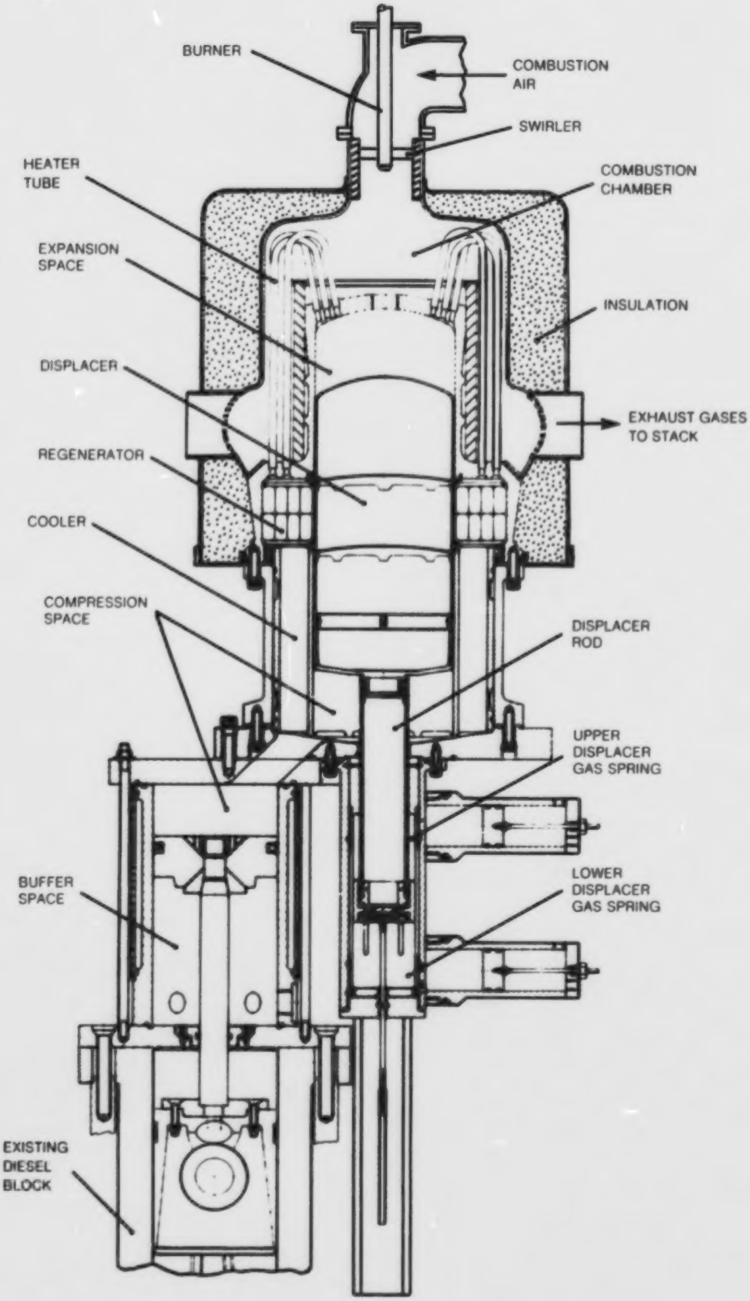


Microprocessor technology promises more efficient maintenance procedures

---

Schedule: March 1982 — January 1985
Funding: TDC-RF — $482,000
Brown Boveri — $252,000

Project Number: 4560
File Number: D-1465-371
Project Officer: M. Audette


BURNER
COMBUSTION AIR
SWIRLER
HEATER TUBE
COMBUSTION CHAMBER
EXPANSION SPACE
INSULATION
DISPLACER
EXHAUST GASES TO STACK
REGENERATOR
COOLER
COMPRESSION SPACE
DISPLACER ROD
UPPER DISPLACER GAS SPRING
BUFFER SPACE
LOWER DISPLACER GAS SPRING
EXISTING DIESEL BLOCK

Conversion of diesel engine to Ringbom-Stirling engine

Stirling Cycle Locomotive Engine

Description

Stirling cycle engines were widely used in the last century as an alternative to steam engines. Stirling cycle engines, like steam engines, are external combustion engines, which were superseded by the internal combustion engine and the electric motor. Rising concern over emission control, energy efficiency and shortages of diesel fuel and gasoline has renewed interest in Stirling cycle engines as they can be powered by a variety of fuels and heat sources. In addition, with the innovative Ringbom-Stirling design, which uses only one seal on the working piston and is charged with relatively low pressure air, many of the seal problems inherent in the classic Stirling cycle engine are overcome.

The objective of this project is to develop and test a small-scale Ringbom-Stirling cycle engine as a preliminary task to the development of a conversion package for a full scale engine. The planned full-scale package will convert the existing MLW 251, 3000 horsepower, four-stroke diesel engine into an air-operated Stirling cycle engine. The heat source of the engine will be a fluidized bed combustor using coal. Sodium vapour heat pipes immersed in the fluidized bed will transport the heat to the engine cylinders.

Investigators will modify to the Ringbom-Stirling cycle a single-cylinder diesel engine rated at 20 horsepower, or thereabouts. A package consisting of a heater, regenerator, cooler and free-piston Ringbom displacer is being designed and manufactured. This package will be bolted to the engine, and the assembly placed on a test bed equipped with a dynamometer. The engine will then be tested and developed until a target figure of 17.4 brake horsepower/litre of swept volume is achieved. This rating is identical to that of a large locomotive diesel, and has been calculated as being achievable with a relatively low pressure, air-filled Stirling engine. Sketch designs of a 3000 horsepower locomotive conversion package for the MLW 251 will also be produced.

Progress to May 1982

The small scale engine package has been designed and is currently being assembled.

Contractor

University of Calgary, Calgary, Alberta

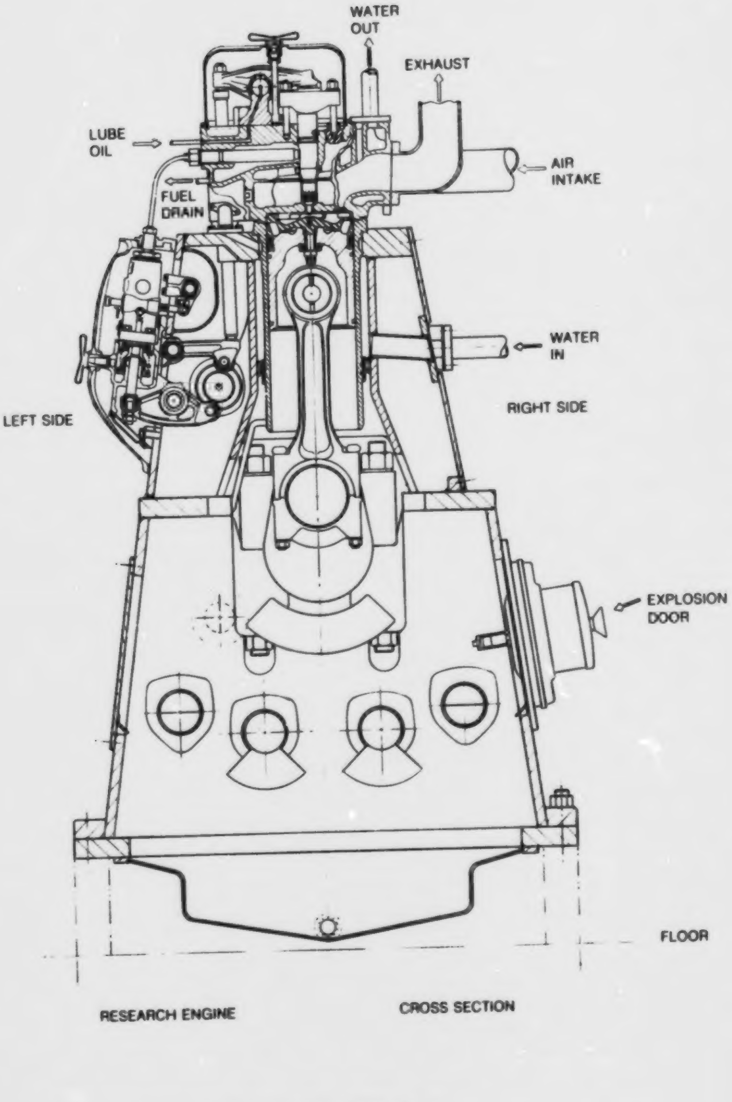
Report

None to date

Schedule: November 1981 — December 1984

Funding: TDC —	$150,000
Energy R&D Panel —	$ 45,000
EMR —	$390,000
DSS —	$120,000
Total —	$705,000

Project Number: 4427
File Number: D-1465-345
Project Officer: R.H. Dillon


WATER OUT
EXHAUST
LUBE OIL
AIR INTAKE
FUEL DRAIN
WATER IN
LEFT SIDE
RIGHT SIDE
EXPLOSION DOOR
FLOOR
RESEARCH ENGINE
CROSS SECTION

Medium-speed diesel engine based on the Bombardier MLW 251 engine

Medium-Speed Diesel Combustion Research

Description

The purpose of this project is to explore the effects on the combustion efficiency and combustion phenomena of a diesel engine when burning off-specification fuels.

Since the entire design of a diesel engine is influenced by the fuel it burns, the anticipated change in fuel characteristics as different world markets are tapped could have a detrimental effect on a given engine design. To study the effects of such fuels, comprehensive tests on an engine with adjustable components are required for fuel assessment.

Under this project a single-cylinder, laboratory-type diesel research engine will be designed and built. It will conform to the configuration of one cylinder of the Bombardier MLW 251 engine, i.e. 190 horsepower or thereabouts. A detailed investigation of the combustion phenomena will be conducted with fuels most likely to be available in the future.

An industrial benefit of this project will be the advancing of Bombardier's technical expertise in the development of locomotive diesel engines.

Progress to May 1982

This project has just started.

Contractor

Bombardier Inc., Montreal, Quebec

Report

None to date

Schedule: April 1982 — February 1983
Funding: TDC-RF — $385,000
Bombardier Inc. — $ 99,000

Project Number: 4558
File Number: D-1465-372
Project Officer: R.H. Dillon

Shunter Locomotive Study

Description

The aim of this project is to develop a fuel efficient shunter locomotive for North American railways.

Locomotives now used for shunting operations are either low horsepower units (250 to 1500 horsepower) of outdated design that do not meet today's requirements for environmental protection and fuel efficiency; or, they are older, general purpose locomotives no longer suitable for mainline use, resulting in severe maintenance problems as well as low fuel efficiency.

The specific objectives of the current study are to establish the technical requirements and design of a diesel shunter locomotive suited to current and projected service requirements, analyze costs and evaluate its market potential in North America.

The design of the locomotive will be guided by the following basic principles:

- optimization of tractive effort within the working speed range;
- maximization of fuel efficiency under all operating conditions;
- compatibility with environmental regulations;
- high reliability and easy maintenance; and,
- low initial cost.

As far as is possible, the new shunter locomotive will be of modular construction and will make use of existing components and sub-assemblies consistent with the design philosophy.

Progress to May 1982

This project has just started.

Contractor

Bombardier Inc., Montreal, Quebec

Report

None to date

Typical shunter locomotive currently in use

Schedule: June 1982 — May 1983
Funding: TDC-RF — $59,600
Bombardier Inc. — $59,600

Project Number: 4588
File Number: D-1465-376
Project Officer: R.S. Nishizaki

Railway Infrastructure

The efficiency and cost-effectiveness of railways is dependent to a significant degree on elements outside the operational deployment of trains. Research is underway to improve infrastructure materials and maintenance procedures and to explore innovative solutions to switching problems caused by the Canadian climate. Projects in this section include:

Intermodal Terminal Operations Simulation aims at developing a computer simulation model and graphical display of the operations of an intermodal container terminal.

Modular Railway/Highway Grade Separation Structures involves the study of using pre-cast and prestressed concrete for grade separation structures in the Quebec-Windsor corridor.

Rail Grinding Optimization aims at improving the rail profile achieved with conventional grinding equipment.

Dynamic Controlled-Climate Test Facility would offer equipment manufacturers and railway operators an alternative to in-service testing of new or modified equipment.

New Railway Track Switch addresses the development of a railway track switch operable in snow and ice without the assistance of a switch heater or other such aid.

Study of Austenitic Manganese Steels for Railways is directed towards improving the wear characteristics of manganese steels.

Intermodal Terminal Operations Simulation

Description

The objective of this project is to develop a computer simulation model and graphical display of the operations of an intermodal container terminal.

The contractor will collect data on intermodal terminal operations and from these develop a computer simulation model. The model will be verified and its flexibility and effectiveness as a planning tool studied in a number of test cases using various container-handling equipment, operating strategies, and terminal layouts.

The key feature of this intermodal terminal operations simulation will be a computer graphical display unit that will convert the information generated by the model into easily understood graphics to facilitate data interpretation for the terminal operator.

Interest in the development of the simulation model grew out of similar work by Canadian National Railway's Operations Research and Industrial Engineering Branch in simulating its piggy back terminal operations. The piggy back simulation proved to be an extremely valuable tool in improving the efficiency with which the railway was able to handle the operation of truck trailers on flat cars. It is hoped that similar improvements in container handling can be realized from the application of many of the lessons learned in the piggy back simulation modelling exercise to this new intermodal terminal operations simulation model.

Progress to May 1982

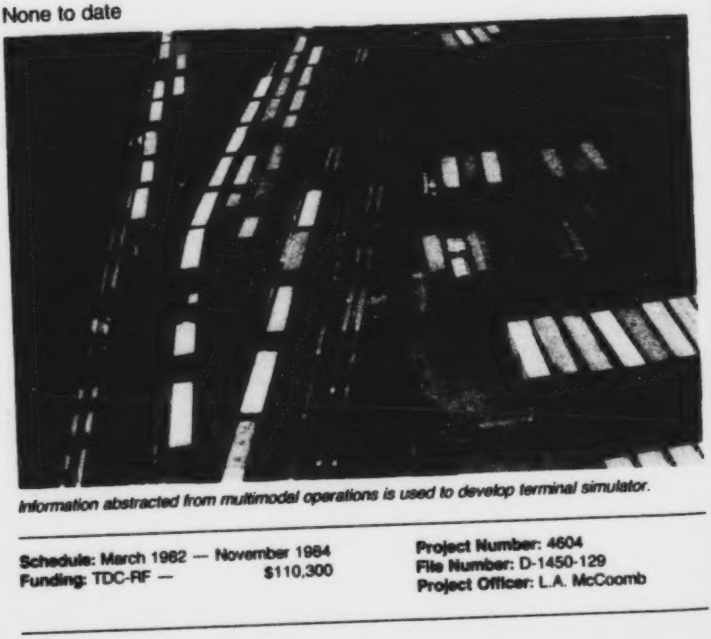
This project has just started.

Contractor

Canadian National Railway, Montreal, Quebec

Report

None to date



Information abstracted from multimodal operations is used to develop terminal simulator.

Schedule: March 1982 — November 1984
Funding: TDC-RF — $110,300

Project Number: 4604
File Number: D-1450-129
Project Officer: L.A. McCoomb

Modular Railway/Highway Grade Separation Structures

Description

The objective of this project is to investigate the cost effectiveness of using pre-cast, and possibly pre-stressed, concrete rail/highway grade separation structures. This method of construction is being considered for application in VIA Rail's Quebec-Windsor corridor.

The contractor carried out a thorough literature review and synthesis on past experience with modular concrete bridge components, particularly in grade separation structures. An assessment of engineering advantages and disadvantages of this type of construction as compared to cast-in-place construction was made, with particular emphasis on structural durability and life cycle costs in the Canadian environment. An integral part of the evaluation was a comparative economic analysis of modular concrete structures and other types of construction (cast-in-place concrete, steel, timber, composite materials, etc.).

Progress to May 1982

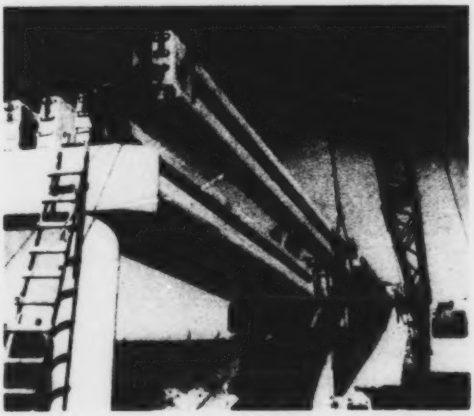
This project is complete. It was found that Canada's two major railways have comparatively few rail bridges of pre-cast, pre-stressed concrete. It is concluded that the circumstances prevalent at the time of the construction of grade separation structures have not been conducive to the standardization of design and thus have not enabled taking full advantage of the potential economic benefits of pre-cast concrete. However, it is also concluded that the introduction of 200 km/h passenger train operation in the Quebec-Windsor corridor will provide an opportunity favourable to the economic use of pre-cast, pre-stressed concrete.

Contractor

Maughan Railway Consulting Services Inc., Montreal, Quebec

Reports

TP 3397, Precast Prestressed Concrete for Railway/Highway Grade Separation Structures, Maughan Railway Consulting Services Inc., March 1982.



Pre-cast, pre-stressed concrete railway bridge in Arlington, Texas

Schedule: October 1981 — March 1982
Funding: TDC — $15,000

Project Number: 4456
File Number: D-1465-358
Project Officer: L.A. McCoomb

Rail Grinding Optimization

Description

The objective of this project is to determine an optimum ground rail profile to facilitate curve negotiation by conventional freight car trucks and to develop a specification for achieving this profile with conventional rail grinding equipment.

This research study includes a review of present grinding practices, development of test instrumentation, assessment of truck curving performance, and computer optimization of rail profiles to minimize curving forces. Selected field test sites will be instrumented, grinder stone settings adjusted and a program of field trials undertaken to gather statistical data for analysis and formulation of rail grinding specifications for optimum truck curving performance.

The results of the work are expected to establish workable preventive maintenance techniques for extending the life of rail in curves, decreasing wheel wear and fuel consumption, and reducing frequency of grinding worn rail. All this would translate into cost savings.

This project also offers Canadian researchers with the opportunity to study and apply rail grinding technology used by Australian heavy-haul railway operators. Mr. S. Lamson of Australia will be directing a research team from the Canadian Institute of Guided Ground Transport, who will be supported by personnel from CP Rail Research and the National Research Council.

Progress to May 1982

A computer model of curve negotiation by freight car trucks was used to determine the optimum rail profile.

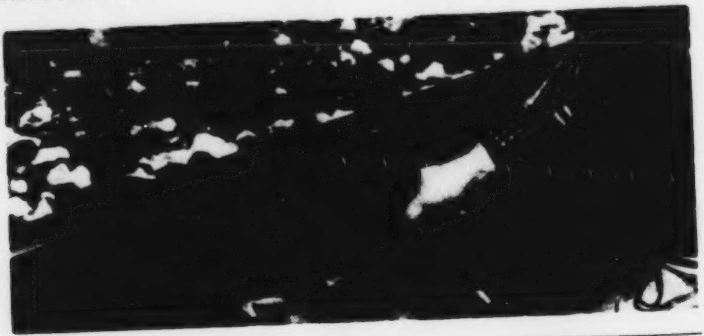
The collection of field test data on freight car truck curving forces and the experimental grinding program have been completed. Data analysis is underway and documentation of the grinding techniques is in preparation.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport,
Kingston, Ontario

Report

None to date



Measuring rail profile before grinding

Schedule: December 1981 — November 1982

Funding: TDC-RF —	$ 78,000
CP Ltd. —	$ 96,800
Railway Association of Canada —	$ 15,400
Total —	$190,200

Project Number: 4562
File Number: D-1465-368
Project Officer: W.G. Rowan

Dynamic Controlled-Climate Test Facility

Description

The overall objective of this activity is to provide a Canadian dynamic (wind tunnel) controlled-climate test facility sized to accommodate rail vehicles and capable of simulating the full range of natural conditions prevalent in Canada and export market countries. The facility would be used primarily to test transportation equipment, but would also be suitable for general applications, such as mechanical/electrical functional testing, environmental medicine studies and military requirements.

Environmental testing of new and modified rail equipment can forestall costly and embarrassing in-service failures. European manufacturers of rail equipment test their products in a dynamic controlled-climate facility at the Vienna Arsenal vehicle testing station in Austria. No dynamic facility capable of accommodating large vehicles, such as rail cars, exists in North America.

The first phase of this project determined the requirements of the railways for a dynamic controlled-climate facility. The objectives of the latest phase are to assess overall demand for a facility, establish functional and technical specifications, carry out preliminary design work, and analyze the cost effectiveness of such a facility.

Progress to May 1982

The survey of the railways concluded that they could make good use of a static controlled-climate test facility that could accommodate rail cars. The railways also expressed cautious interest in a dynamic test facility, particularly one that would be shared with other users. Some interest in a dynamic facility was also expressed by the other prospective users.

The requirements analysis concluded that there is insufficient demand for an independent test facility. The National Research Council, however, is building a new 30.5 m cold room and TDC is exploring the practicability of upgrading it to a dynamic facility.

Contractor

DSMA International Ltd., Toronto, Ontario

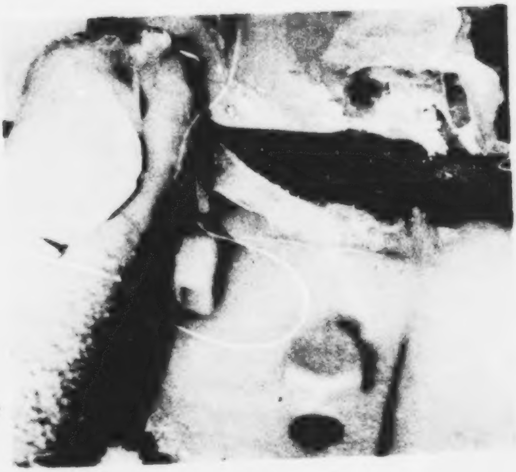
Report

TP 2691, Railway Perspective of Controlled-Climate Testing, 2 volumes, Canalog Logistics Ltd., August 1980.

Schedule: June 1981 — November 1982
Funding: TDC-RF — $174,000

Project Number: 4089
File Number: D-1465-285-6
Project Officer: R.S. Nishizaki

New switch in ice



Switched to other track

Returned to original position

New Railway Track Switch

Description

The objective of this project is to design, fabricate and test a prototype railway track switch operable in snow and ice without the assistance of a switch heater or other such device and suitable for a powered, high-speed mainline application in signalled territory.

A split switch is used almost exclusively in railway track work throughout North America and around the world. It performs its function relatively well and requires little maintenance; however, if even a small amount of snow or ice accumulates between the point rail and the stock rail, the switch will fail to fully close when thrown, as the snow compresses into a solid mass with considerable strength.

For many years this problem was overcome by sweeping the snow away from critical areas with hand brooms. But this action did not entirely eliminate train delays caused by switches rendered inoperable by snow and ice; in fact, it resulted in high labour costs. Efforts to reduce train delays and labour costs led to the development of various types of switch heaters and blowers that are now in widespread use on Canadian and other railways. Such devices consume large quantities of fuel and require a considerable capital investment, as well as substantial maintenance for repair, adjustment and refuelling.

A design of a railway track switch that operates in ice and snow exists and is based in part on the horizontal traverse switch developed by the National Research Council. As a first step toward achieving the objective of this project, researchers will develop the conceptual design for a powered switch and establish suitable track geometry to permit its use with a CN Rail turnout using 136 lb RE rail and concrete ties.

Positive results from this work would contribute to the productivity and efficiency of winter train operations and to the economy of switch maintenance.

Progress to May 1982

Phase one of this project has just started.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

None to date

Schedule: March 1982 — March 1983
Funding: TDC-RF — $75,000

Project Number: 4575
File Number: D-1465-369
Project Officer: W.G. Rowan

Study of Austenitic Manganese Steels for Railways

Description

Increased traffic and heavier axle loads have greatly accelerated the wear rates of crossovers, bridge wedges and "frogs" (devices on tracks for keeping cars on the proper rails at intersections or switches). This wear results in significant maintenance requirements and causes costly downtime. The material currently in use for these components is explosively-hardened Hadfields manganese steel.

The objective of this project is to develop an austenitic manganese steel with improved resistance to adhesive and abrasive wear and to plastic deformation, and capable of being cold-straightened at the foundry. The steel must also have a satisfactory response to explosive hardening and exhibit acceptable welding characteristics.

Investigators will study the effect of alloy additions to the steel currently used. Vanadium has been identified as having good potential to increase resistance to wear and plastic deformation. Investigations will then be made into the weldability of candidate alloys to conventional steel rails.

Progress to May 1982

A comprehensive literature search was completed on manganese steel. A large number of melts have been made for testing.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

None to date

"Frog"

Schedule: November 1981 — October 1982
Funding: TDC-RF — $88,300
CP Ltd. — $29,800

Project Number: 4467
File Number: D-1467-359
Project Officer: R.H. Dillon

Signalling, Communications and Control

The application of electronic technology to the signalling, communications and control of rail operations has become increasingly important in recent years. Methods of signalling and communicating that were effective in the past cannot always satisfy the present day efficiency demands of a competitive transportation mode.

Glenayre Electronics, in a project commissioned by TDC, has developed the **Radio-Linked Train Location, Identification and Control (LIC) System**, which provides dispatchers with continuous real-time monitoring of the location of individual trains. The LIC system is a more economical signalling method than the centralized train control (CTC) now commonly used on mainline track and is expected to reduce headways and thereby increase track capacity on many sections of Canadian single track railway lines not equipped with CTC signalling. It provides in-cab signals to the engineman and is recognized to have potential for improved schedule adherence as compared with automatic block signalling. The LIC system was tested in prototype form by BC Rail and is now part of an extensive demonstration and evaluation program on its Squamish subdivision. A **Study of LIC Application on Mainline Track** is also underway.

Other projects in this section are:

Automatic Rail Car Identification System: the development of a reliable and accurate system to identify rail cars.

Field Test of Inductive Trainline Connector: the study of an inductively coupled communications line as a means to improve freight train communications and control.

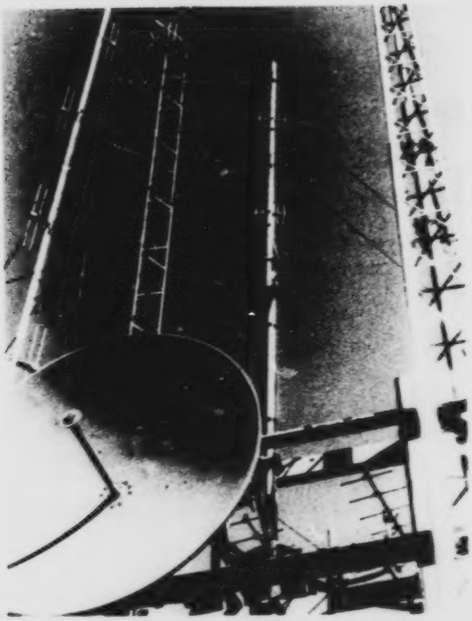
Train Data Recording System: the application of microprocessor technology to an automatic train data recorder.

Control of Long Freight Trains: the investigation of closed-loop control systems for long freight trains.

Locomotive Speedometer Evaluation: the development of a speedometer unaffected by wheel and rail wear.

On-Board Hotbox Detection System: a system that would resolve concerns regarding the appropriate spacing for the wayside detectors now in use.

Cab Information Display for High Ambient Light Conditions: the development of a cab information display suitable for computer-controlled vehicles with high ambient light conditions.



Antenna used by BC Rail to transmit LIC signals

BC Rail dispatch centre with LIC equipment

Radio-Linked Train Location, Identification and Control (LIC) System — Operational Demonstration

Description

In the past several years, BC Rail and Glenayre Electronics Ltd. of Vancouver, with the coordination and financial support of TDC, have been developing a single-track railway location, identification and control (LIC) system. The current project involves the implementation and operational demonstration of the LIC system on the Squamish subdivision of BC Rail.

The operational demonstration will allow researchers to identify and resolve any remaining developmental problems. It will provide the operational experience, data on reliability and proven record of safety necessary for operational exploitation. The development of all LIC hardware and software will be completed during the implementation phase. Modifications to the hardware reflecting the extensive field experience to date have been effected by Glenayre Electronics. Glenayre is contracted to provide electronic equipment for 33 lead locomotives and 30 cabooses, and the data processing equipment for the dispatch centre.

During the demonstration, all train movements throughout the full 250 km length of the Squamish subdivision will be monitored and controlled. Following an initial period of operation in parallel with the manual system, the LIC system will be used alone to monitor and control train operations.

The demonstration is expected to verify the suitability of this type of system for traffic control on low or medium density railway lines now operating under manual control and to determine whether its use on high density lines would permit reduction of headways, thus improving physical capacity.

Progress to May 1982

Purchase orders for all the LIC equipment have been placed with the manufacturer, Glenayre Electronics Ltd. To date approximately 50 per cent of the locomotive hardware has been installed. The dispatch centre has been completed and system software is under test. Trial operation of the system is expected to begin late in 1982.

Contractor

British Columbia Railway, Vancouver, British Columbia

Report

TP 1993, Train Location, Identification and Control Prototype System, BC Rail, February 1979.

Schedule: January 1979 — November 1983
Funding: TDC — $1,662,000
Prov. of B.C., Ministry of Economic Development — $ 831,000
BC Rail — All additional costs

Project Number: 8929
File Number: D-1465-128-7-3
Project Officer: N.E. Rudback

Study of LIC Application on Mainline Track

Description

The objective of this study is to evaluate the feasibility of utilizing the LIC system on mainline railway track. The improved safety and increased line capacity that would result from successful LIC development for mainline use are of prime importance to Transport Canada.

TDC has been supporting Glenayre Electronics and BC Rail in the development of LIC signalling technology since 1975. In 1978, the feasibility of the LIC concept was demonstrated when a small experimental system was put into trial operation in parallel with the manual control system. The success of this project led to plans for the full-scale development and operational demonstration of LIC signalling throughout the Squamish subdivision of BC Rail. Development work is now well advanced and LIC operation on the subdivision is scheduled to start in 1983.

While the demonstration on BC Rail is an essential step in the development process, the system to be evaluated does not incorporate all the features required for application to mainline railways. Further development work is therefore necessary to identify and provide design solutions to the additional signalling required for mainline railway operation and for certification by the Canadian Transport Commission.

This project is a first step in the process of developing the LIC system for mainline application. The contractor will carry out technical studies and a design analysis, and prepare the software and test work for the development of a data processor. A site-specific study will be made into the application of the LIC system on typical sections of mainline railway track.

Progress to May 1982

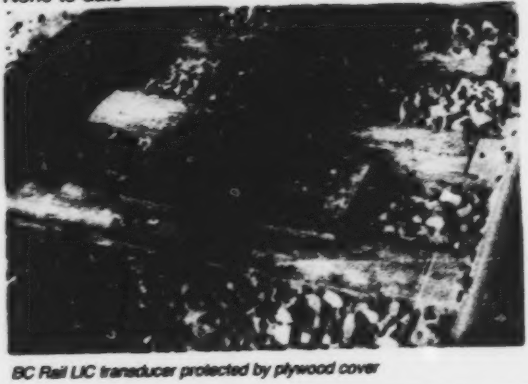
The contractor is cooperating with CN Rail and CP Rail in the preparation of a specification for an electronic signalling system. Work on adapting the data processing to accommodate additional features necessary for mainline application is well underway.

Contractor

Glenayre Electronics Ltd., Vancouver, British Columbia

Report

None to date



BC Rail LIC transducer protected by plywood cover

Schedule: March 1982 — December 1983
Funding: TDC-RF — $490,000

Project Number: 4510
File Number: D-1465-128
Project Officer: N.E. Rudback

Automatic Rail Car Identification System

Description

The aim of this project is to improve railway operating efficiency through the development of an automatic car identification system.

In the mid-1960's, the railways developed a standardized optical system for automatic car identification, but the system did not meet expected performance levels and was removed from service in 1977. The need for a highly reliable, accurate system for automatic rail car identification remains, as it would provide railways with substantial operating benefits by eliminating manual reading of labels on each car departing or entering a terminal.

The specific objective of this project is to develop and test a passive rail car identification transponder, a field programming unit to set the car number in the transponder, and a controller/interrogator to read the transponder.

The successful development of a practical automatic car identification system would benefit not only railways but also other transportation operators including bus and truck companies.

Progress to May 1982

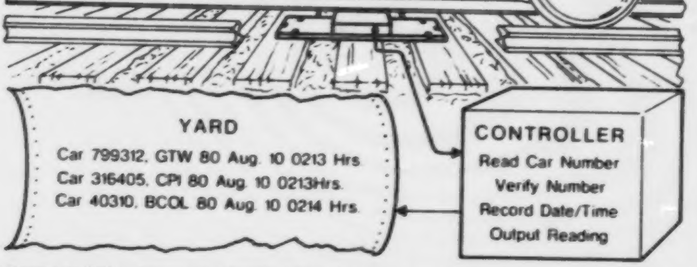
The contractor has developed an experimental prototype transponder, which is now under test. When these tests are completed, 100 units will be constructed for testing in operational service.

Contractor

Glenayre Electronics Ltd., Vancouver, British Columbia

Report

None to date

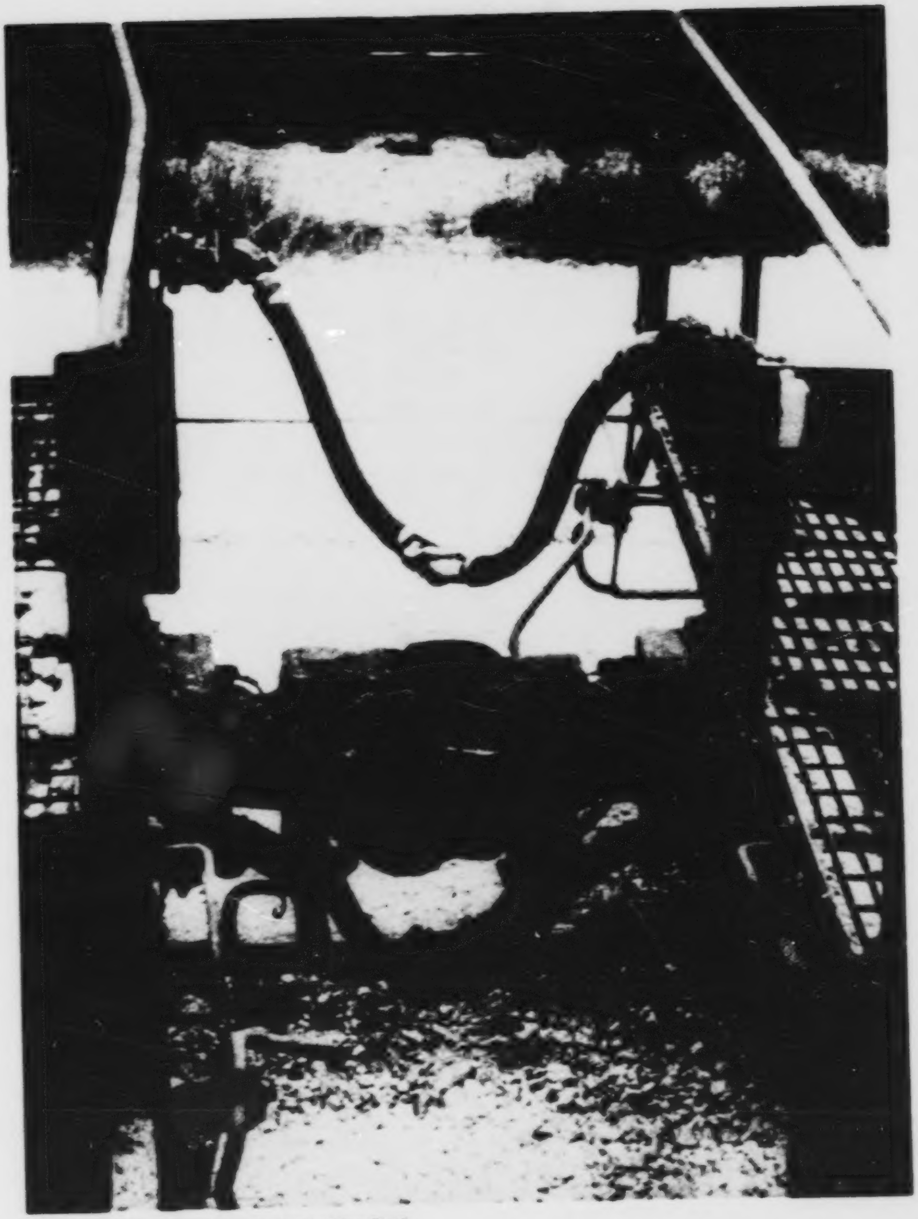

Passive transponder on rail car
YARD
Car 799312, GTW 80 Aug. 10 0213 Hrs.
Car 316405, CPI 80 Aug. 10 0213Hrs.
Car 40310, BCOL 80 Aug. 10 0214 Hrs.
CONTROLLER
Read Car Number
Verify Number
Record Date/Time
Output Reading

Glenayre's Railocator — an automatic rail car identification system

---

Schedule: March 1982 — December 1983
Funding: TDC-RF — $250,000
DSS — $170,000

Project Number: 4436/4437
File Number: D-1465-347
Project Officer: N.E. Rudback



Inductive trainline connector under test in Nova Scotia

Field Test of Inductive Trainline Connector

Description

In 1971, the Canadian Institute of Guided Ground Transport (CIGGT) studied the feasibility of a communications system that would help improve the safe and efficient handling of long freight trains. During that study, the concept of the inductive connector emerged as the most promising way of connecting a transmission line between rail cars. Electrical connectors were not considered sufficiently rugged or reliable for the harsh railway environment.

An inductively coupled transmission line would make possible the use of a train monitor system to detect and warn of incipient hazard. It would permit on-board detection of overheated bearings, leakage or expansion of dangerous cargo and wheels-on-track/derailment. It would also permit measurement of draft-gear forces, and brake pipe pressure at the tail end. In unit trains with locomotives at different points in the train, the transmission line would provide a more reliable, interference-free alternative to the two-way radio now used. CIGGT conducted a series of laboratory experiments that verified the technical feasibility of an inductively coupled transmission line, and subsequently calibrated a mathematical model to predict the performance of a trainline using these couplings.

Following the initial experiments, TDC, CP Rail and CN Rail jointly funded a CIGGT project to construct and test under controlled conditions an experimental signal transmission line with sixty pairs of inductive connectors. The connectors seem to have the ruggedness and reliability needed to make the on-board transmission line workable.

Building on the CIGGT work, the current project involved designing and preparing a suitable trainline for testing on a unit gypsum train equipped with instrumentation to measure the performance of the connectors.

Progress to May 1982

This project is complete. In late spring 1981, researchers installed inductive connectors on a 35-car unit train operated by CP Rail in Nova Scotia. These connectors operated in the field for over a year. They were tested at regular intervals and the results corresponded with those of the laboratory tests. It is concluded that the inductive connector has all the features required for a workable on-board transmission line.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

Draft, Field Testing of Inductive Connectors, Queen's University, Canadian Institute of Guided Ground Transport.

Schedule: July 1981 — March 1982

Funding: TDC —	$30,000
CP Rail —	$30,000
CN Rail —	$30,000
Total —	$90,000

Project Number: 4270
File Number: D-1465-158-5
Project Officer: C.A. Versailles

Train Data Recording System

Description

Existing train data recorders using magnetic tape frequently suffer mechanical failures attributable to the harsh operating environment. Canadian railway officials have indicated the need for a rugged, reliable and economic train data recording system capable of logging twenty or more parameters continuously for two or more days.

The objective of this project is to develop an innovative train data recording system using solid-state microprocessor technology. The envisaged system would employ a recorder mounted in the locomotive, an optional CRT display unit for the engineman, a playback unit consisting of a keyboard, control unit and teletype printer in a fixed location, and a portable memory transfer unit.

In the first phase of this two-phase project, the contractor will design and fabricate one prototype of each system component. The recorder will be installed in a CP Rail locomotive and all system components will be functionally tested to verify the design. System design modifications will be made based on the test results.

Assuming satisfactory results in phase one, phase two will involve the construction and field testing of several prototype recording units. Environmental and vibration testing will also be conducted to ensure that the design meets the railway operational requirements. Phase two work will culminate in a final design package suitable for mass production.

Progress to May 1982

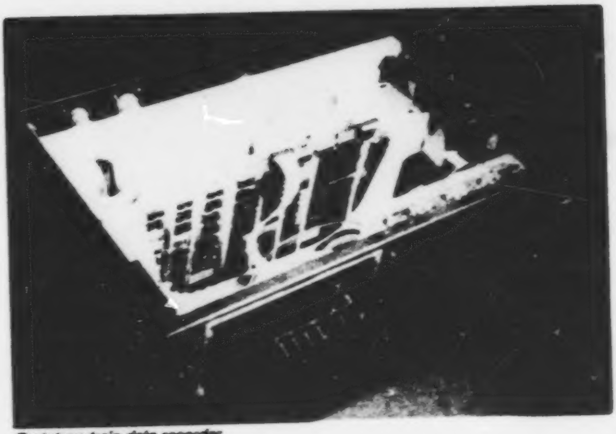
The hardware design is nearing completion and system components are being tested in the laboratory. Software design is underway.

Contractor

MPB Technologies Inc., Montreal, Quebec

Report

None to date



Prototype train data recorder

Schedule: October 1981 — October 1983
Funding: TDC-RF — $ 99,400
DSS — $134,000

Project Number: 4462
File Number: D-1465-357
Project Officer: W.G. Rowan

Control of Long Freight Trains

Description

The objective of this project is to investigate, simulate and develop closed-loop control schemes for the handling of long freight trains.

The braking system most often used today for freight cars and locomotives is the compressed air system. The major disadvantages of the compressed air brake are: relatively slow activation times for cars more distant from the locomotive, limited control of the degree of braking force applied, and open-loop mode of operation.

Increased train control efficiency might be achieved through the introduction of new train control and braking technology. This requires a reliable communication line along the freight train together with a closed-loop train control scheme and electro-pneumatic braking capability. The communication line development is being addressed in the study of an inductive trainline connector described on p. 49.

This project addresses the development of train control schemes utilizing the closed-loop mode and based on the adaptive control schemes previously developed by Professor M.M. Bayoumi of Queen's University. The results of this work will help improve the safety, productivity and efficiency of long freight trains.

Progress to May 1982

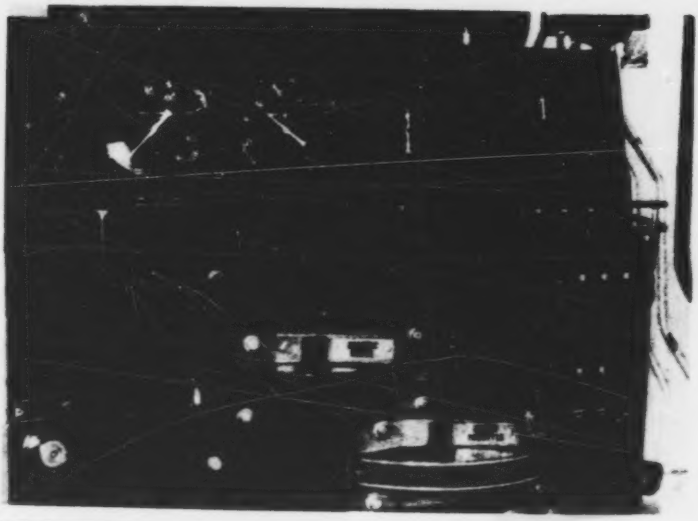
The computer simulation model has been modified and extended and is now being tested.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport,
Kingston, Ontario

Report

None to date



Train control station on CP locomotive

Schedule: December 1981 — December 1983
Funding: TDC-RF — $130,000

Project Number: 4471
File Number: D-1465-265
Project Officer: W.G. Rowan

Locomotive Speedometer Evaluation

Description

The purpose of this project is to provide Canadian locomotives with speedometers whose operation is not sensitive to wheel wear or to slippage between the rail and wheel under traction or in braking operations.

Operational restrictions necessitate accurate measurement of the speed of passenger and freight locomotives to ensure that speeds for which crossing signal circuits are set are not exceeded and to avoid damage caused by high speed shunting operations.

A previous TDC/Railway Advisory Committee project identified a radar speedometer produced by CMI of Colorado as being best able to satisfy the requirements of the railways.

In the current project a field evaluation of the CMI radar speedometer will be undertaken. Twelve units will be purchased for installation on two classes of CN locomotives operating in three geographical regions, the Atlantic provinces, Central Canada and Western Canada.

Initial work will include a short-term, controlled test to characterize the performance of the speedometers in specific situations, such as over water, ice and open trestles, and at low speeds. The speedometers will then be monitored and evaluated for a minimum of two years.

Progress to May 1982

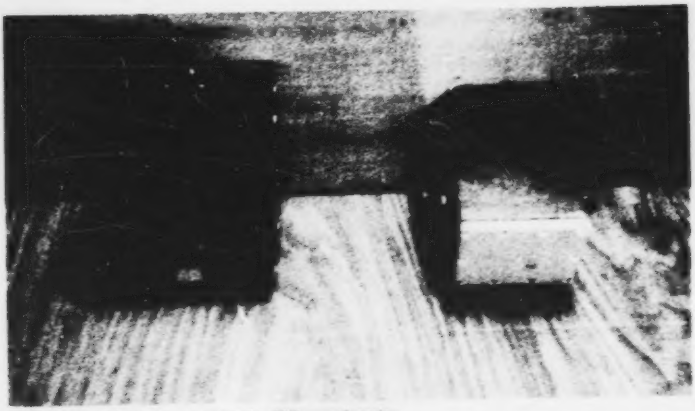
Work on this project has just started. An order has been placed for the trial speedometers.

Contractor

Canadian National Railways, Montreal, Quebec

Report

None to date



Transducer and display module of a CMI speedometer

Schedule: December 1981 — March 1984
Funding: TDC-RF — $40,000
CN Rail — $30,000 (in kind)

Project Number: 4530
File Number: D-1465-285-9
Project Officer: D.W. Dibble

On-Board Hotbox Detection System

Description

The objective of this project is to develop an effective and reliable on-board hotbox detector that would help prevent derailments caused by the failure of journal and roller bearings. The development of such a system would resolve the concerns regarding appropriate spacing of the wayside detectors now used by major Canadian railroads.

This project will involve a literature and patent search and a review of on-board hotbox detectors developed or proposed. The contractor will first evaluate selected systems against a technical specification to be prepared by CN Rail and CP Rail. Where warranted, in-service testing will follow. If no suitable system is found, the development of a new detector will be undertaken.

The safety benefits to the railway industry and to the Canadian public of a reliable and efficient detection system that could eliminate the majority of derailments caused by bearing failure would be significant.

Progress to May 1982

The technical specification is being developed. The literature and patent search has identified several detectors for the evaluation process.

Contractor

DSL Dynamic Sciences Limited, St. Laurent, Quebec

Report

None to date

Hotbox incident

Schedule: March 1982 — December 1982

Funding: TDC-RF —	$ 37,000
CP Rail —	$ 33,000
CN Rail —	$ 33,000
Total —	$103,000

Project Number: 4508
File Number: D-1465-362-2
Project Officer: D.W. Dibble

Cab Information Display for High Ambient Light Conditions

Description

New electronic communication, command and control systems promise to improve significantly the safety and efficiency of surface transportation systems. But the lack of a satisfactory in-vehicle electronic display unit is hampering the development and exploitation of vehicle control technology, such as the LIC system described on page 45. Although the problem was resolved for the test demonstration of the LIC on BC Rail, a new display unit capable of operating under all ambient light conditions is needed for future LIC installations.

Improved in-vehicle displays are also needed for bus, truck, taxi and other vehicle control systems, such as one being developed for a diesel/electric truck used in open pit mining operations.

This project investigated two new display technologies, vacuum fluorescent and dot matrix liquid crystals, and evaluated their effectiveness for a locomotive cab or other transportation applications with high ambient light condition.

Progress to May 1982

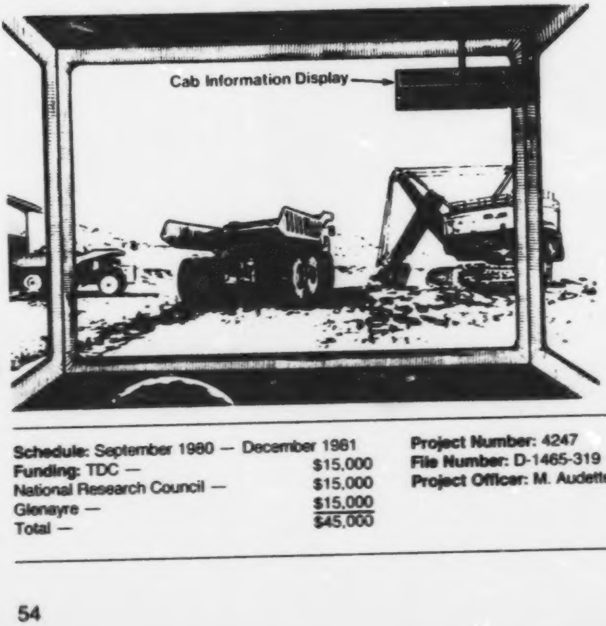
This project is complete. Display modules based on the two technologies were built into single-line, 40-character experimental cab displays. Interface equipment was developed to operate the displays, and evaluated under both laboratory and field operating conditions. Results indicate that while the readability of vacuum fluorescent technology is superior to that of plasma gas discharge, problems in extremely bright ambient light conditions remain with both technologies.

Contractor

Glenayre Electronics Ltd., Vancouver, British Columbia

Report

TP 3630E, Locomotive Cab Information Display, Glenayre Electronics Ltd., December 1981.



Display module in high ambient light environment

Schedule: September 1980 — December 1981

Funding: TDC —	$15,000
National Research Council —	$15,000
Glenayre —	$15,000
Total —	$45,000

Project Number: 4247
File Number: D-1465-319
Project Officer: M. Audette

Railway Passenger Projects

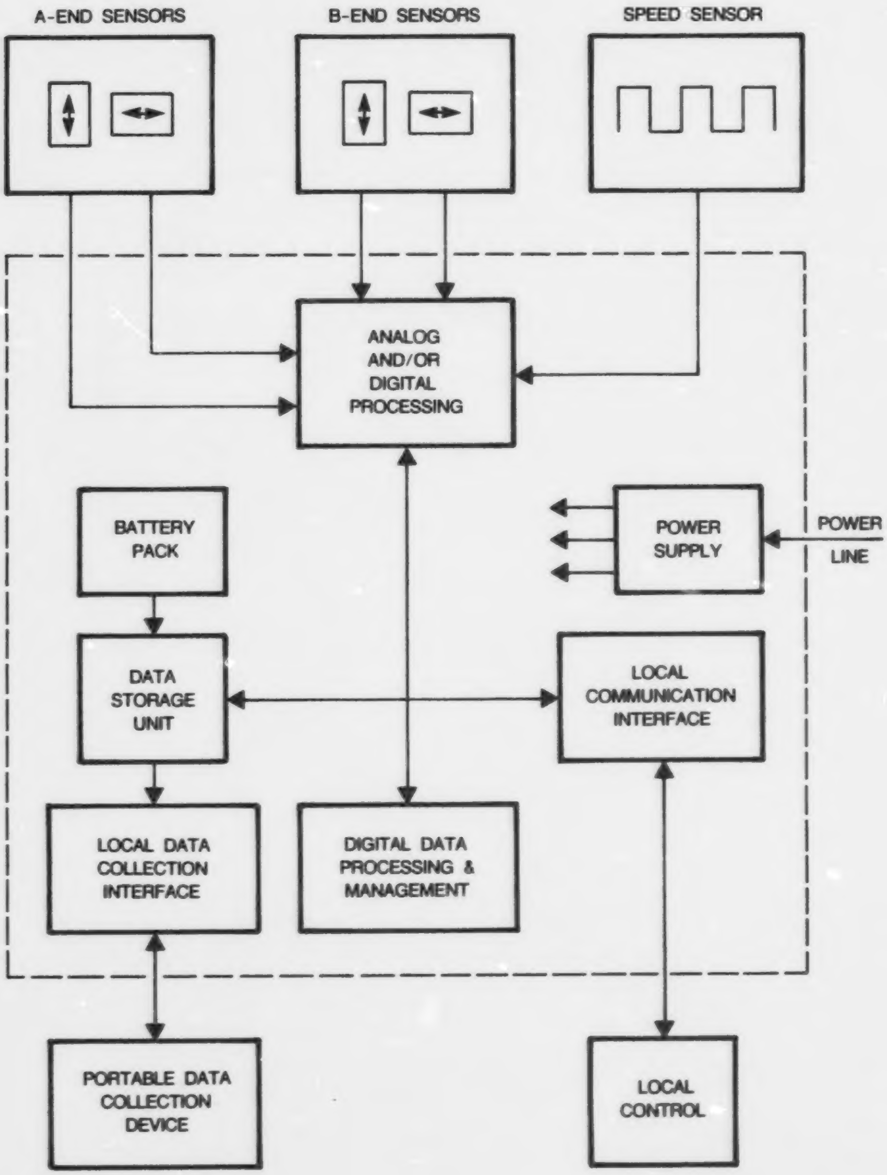
Transport Canada's rail passenger policy is aimed at rejuvenating this traditional transportation mode.

Existing intercity rail cars must be updated and new equipment acquired to provide train passengers with a level of comfort and an ambience in keeping with modern times. TDC has undertaken research and development in these areas to ensure that the rail mode remains an attractive and efficient intercity transportation option. For **Ride Monitoring System for Rail Vehicles**, researchers are developing a system to monitor ride characteristics of rail vehicles so as to maintain or improve ride quality and facilitate maintenance scheduling; and, for **Instrumentation of Wheelsets**, investigators are collecting the data needed to establish maximum permissible operating speeds for new trains.

TDC played a major role in the design, development and testing of VIA Rail's new LRC train. TDC supplied financial and management support for the testing and evaluation of the prototype locomotive and coach, which were exposed to the most comprehensive railway passenger equipment testing program in Canadian history. TDC also contributed to the development of the train's passenger seats; its involvement included writing performance specifications, sponsoring the design and testing of the seat and, finally, conducting an in-service evaluation by passengers.

BC Rail and VIA Rail have introduced into service modernized rail diesel cars based on engineering studies commissioned by TDC.

TDC has also undertaken projects aimed at understanding the requirements of current and potential train users, and forecasting their response to improvements in service. The prediction approach is based on the study of specific trips through traveller surveys and the quantification of the criteria by which they choose a particular mode. In recent work, nine routes in Western Canada were investigated to assess the feasibility of introducing LRC trains to this region.


A-END SENSORS
B-END SENSORS
SPEED SENSOR
ANALOG AND/OR DIGITAL PROCESSING
BATTERY PACK
POWER SUPPLY
POWER LINE
DATA STORAGE UNIT
LOCAL COMMUNICATION INTERFACE
LOCAL DATA COLLECTION INTERFACE
DIGITAL DATA PROCESSING & MANAGEMENT
PORTABLE DATA COLLECTION DEVICE
LOCAL CONTROL

Functional diagram of logic controller of the ride monitoring system

Ride Monitoring System for Rail Vehicles

Description

The objective of this project is to develop a system to monitor rail vehicle ride characteristics for maintenance of track and equipment and evaluation of passenger ride quality.

In Britain and Japan, railways routinely measure the ride quality of their high speed passenger equipment. The data are used to find track alignment problems and assess vehicle maintenance requirements. The data collection and analysis methods used by both countries are quite labour intensive, and require considerable data reduction and analysis.

For this project the contractor will study the techniques used by Japanese National Railways, British Rail and other railways. Data processing methods suitable for automation will be reviewed and the experiments and tests necessary to verify the data processing techniques will be specified. Techniques for keying data to train location will also be investigated.

The contractor will define alternatives for a monitoring system that will provide vehicle and track maintenance information and routine data on ride quality in actual service. Methods to measure and evaluate human comfort will also be reviewed.

Progress to May 1982

The contractor has defined a concept for a ride monitoring system. VIA Rail has expressed an interest in this project and will review the concept before TDC continues its development.

Contractor

DSL Dynamic Sciences Limited, St. Laurent, Quebec

Report

Draft, Vehicle Ride Monitoring System, DSL Dynamic Sciences Ltd.

Schedule: October 1981 — June 1982
Funding: TDC — $15,000

Project Number: 4518
File Number: D-1465-278-2
Project Officer: D.W. Dibble

Instrumentation of Wheelsets

Description

The purpose of this project was to develop instrumentation that could be used to demonstrate the compliance of new rail passenger equipment, particularly the LRC passenger train now in service with VIA Rail Canada, with current specifications defining limiting lateral and vertical force criteria. This is necessary in order to establish the maximum permissible operating speed for new trains. To this end, a railway locomotive wheelset was instrumented to enable comparative testing with the baseline reference locomotive, a General Motors model FP9A (CN Rail class GPA-17).

Work on this project included:

- definition of an instrumentation system and component specifications;
- design and verification of the system, including signal pick-up, processing and recording units;
- collaboration with the CN Rail Research Centre to determine locations for the installation of the instrumentation and a methodology for its application to the locomotive wheelset; and,
- field tests using the instrumentation system on a class GPA-17 locomotive.

Progress to May 1982

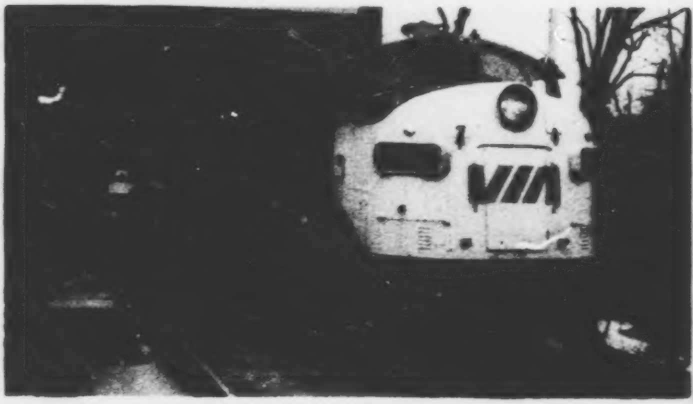
The instrumentation system was calibrated and installed on a GPA-17 locomotive for field tests. Two days of tests were conducted on yard track and one day on mainline track. With the exception of intermittent signals from one pick-up point, the system performed well.

Contractors

National Research Council, Ottawa, Ontario
CN Rail Research Centre, St. Laurent, Quebec

Report

None to date



GPA-17 locomotive with instrumented wheelset

Schedule: August 1977 — August 1982
Funding: TDC — $50,000
VIA Rail — In kind

Project Number: 7451, 7452, 4444, 4527
File Number: D-1465-231-2
Project Officer: D.W. Dibble

Surface Technology

Intercity Road Technology **61**

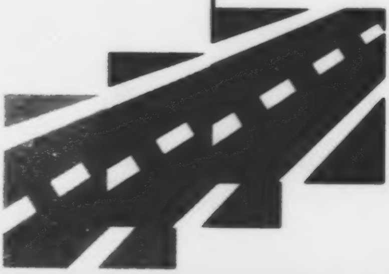
Innovative Urban Transit Technology **67**

Tracked Levitated Vehicle Technology **75**

Off-Road Vehicles **79**

Alternative Energy Sources **83**

Transportation for the Mobility Handicapped **93**



Intercity Road Technology

The extensive system of roads crisscrossing Canada form the most flexible transportation mode available to the Canadian traveller.

The identification of research projects related to road transportation is complicated by the fact that highway users — drivers or operators of trucks, automobiles and buses — have disparate interests and needs. Still other interests are expressed by the provincial transport departments, which regulate and maintain the highways.

The many research projects in this section demonstrate TDC's awareness of these needs. Several projects are aimed specifically at improvements in intercity bus technology. These include:

Articulated Intercity Bus Testing and Evaluation: the study of a high capacity bus specifically designed for Canadian intercity operations.

Intercity Bus Fuel Efficiency: a look into aerodynamic design changes to improve bus fuel efficiency.

TDC has also completed preliminary studies of a double-deck bus design. As a follow-on of its work in high capacity bus design, TDC is planning a project to define the market characteristics of high capacity buses. The study will also address the legal and other restrictions affecting the development of high capacity buses.

Other road technology projects include the study of the **Efficient Use of Bituminous Cement for Canadian Highways**, which examines the recycling of asphalt and the use of additives such as rubber or sulphur to reduce costs; the development of a **Highway Pavement Strength Testing Vehicle**; and, a study of **Compliant Air Bearings to Assist Intermodal Cargo Transfer**, a system that uses compressed air to move cargo on pallets over tracks.

Articulated Intercity Bus Testing and Evaluation

Description

This project aims to stimulate intercity bus services by the development of innovative, Canadian-made articulated intercity buses.

TDC is participating with Voyageur Inc., a subsidiary of CSL Group Inc., in a technical, operational and economic assessment of articulated intercity bus service in Canada.

Based on the findings of a TDC feasibility study on high capacity intercity buses in Canada and on information obtained from European manufacturers of such equipment, the German-made Neoplan Highliner bus was selected for testing on one Voyageur route.

The Neoplan was modified to conform with operational standards set by Voyageur. During the winter of 1980/81, tests were conducted to compare handling and human engineering aspects of the articulated bus with those of a conventional MC-9 bus. Results show that performance and stability of the two buses were comparable except for the Neoplan's poorer traction and higher interior noise levels.

Progress to May 1982

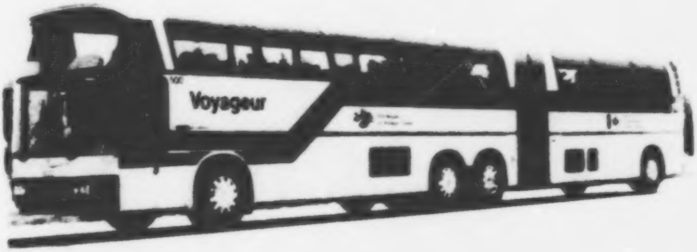
The Neoplan articulated bus began service on Voyageur's Montreal-Ottawa route in December 1981. By April 1982 it had operated over 25,000 kilometres, experiencing only minor problems. The unit had to be withdrawn from service upon discovery of cracks in the hinge mechanism. This defect is being corrected and testing is expected to resume in the fall of 1982.

Contractor

Voyageur Inc., Montreal, Quebec

Report

None to date



Schedule: May 1979 — March 1983
Funding: TDC — $240,000
CSL Group Inc. — $240,000

Project Number: 8959
File Number: D-1465-280-3
Project Officer: T. Smith

Intercity Bus Fuel Efficiency

Description

The overall objective of this project is to improve the fuel efficiency of intercity buses. The specific objectives are to develop baseline fuel consumption data on a variety of buses at highway cruise speeds; to determine the effect of rolling resistance and aerodynamic drag on fuel consumption; and, to evaluate the potential of aerodynamic modifications to reduce fuel consumption.

Eight different buses supplied by Voyageur Inc. were used for testing. These were the MC9 series 1900 and 1800, the MC7 and MC8, the Prévost Mirage and Prestige, the GM 4905 and the Eagle Model 10.

Progress to May 1982

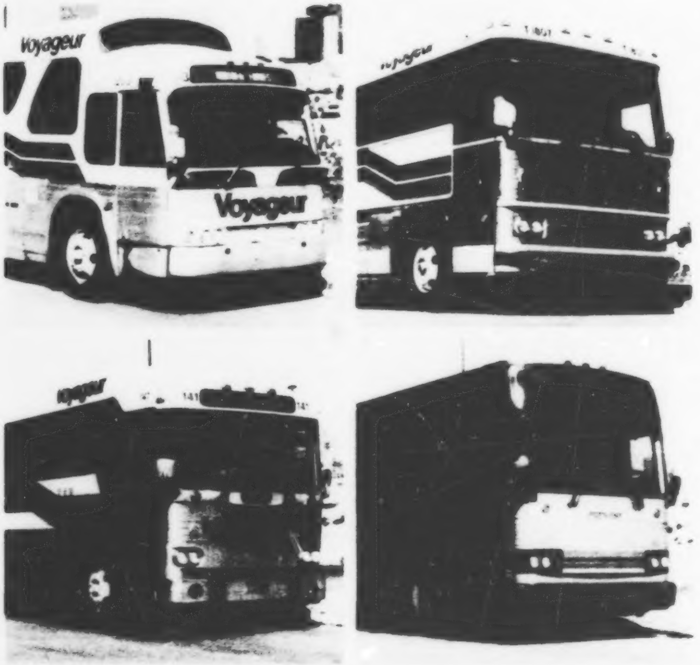
Measurements of fuel consumption were made on all eight bus models for a range of highway cruise speeds. Four aerodynamically different models were then selected for coast-down tests. Results indicate that substantial fuel savings could be realized by aerodynamic modifications to bus design. A report is in preparation.

Contractor

TES Limited, Ottawa, Ontario

Report

None to date



Four of the bus models tested

Schedule: August 1981 — March 1983
Funding: TDC — $30,000

Project Number: 4407
File Number: D-1465-339
Project Officer: B. Marshall

Efficient Use of Bituminous Cement for Canadian Highways

Description

Bituminous cement, asphalt, is used extensively as a binder for flexible pavements. World demand for petroleum and fuel oils is driving up the price of petroleum by-products such as asphalt, while shrinking their availability. The rising cost and the diminishing supply of asphalt are major concerns in the design, rehabilitation and maintenance of highways. More efficient use of this product would result in cost and energy savings.

Some road and highway authorities are experimenting with additives, such as sulphur, to replace in part the more expensive asphalt; others are relying on a hot-mix recycling of asphalt pavements to cope with increased costs. TDC sees merit in both these approaches, but information on the techniques used and their benefits is not widely available.

TDC has defined two studies into the use of asphalt. In one study investigators will document the state of the art of hot-mix recycling. The various techniques will be assessed and the results will be made available to all Canadian road and highway authorities in the form of a user manual so as to encourage their use nationally.

The second study will investigate current practices in the use of additives such as sulphur and rubber. These additives not only reduce costs, but also offer technical benefits such as reduced oxidation and improved wetting capability, adhesion and flow properties. TDC will then formulate a program of research and testing to validate the findings of the study.

Progress to May 1982

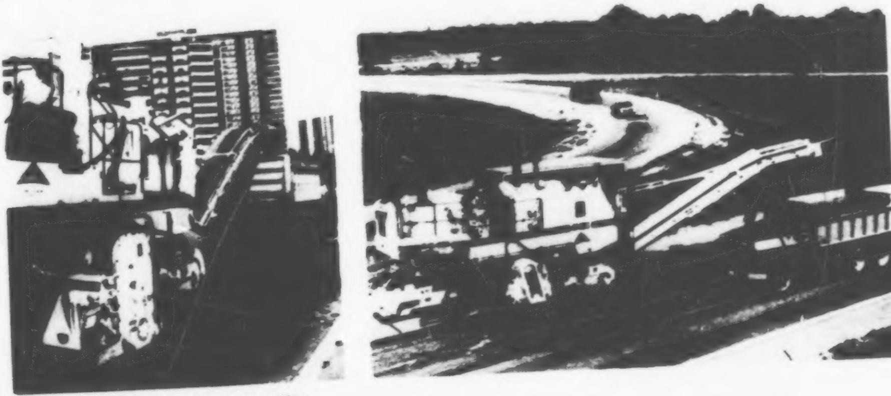
The literature searches required for both these studies have been completed. The contractor is preparing the reports.

Contractor

Roads and Transportation Association of Canada, Ottawa, Ontario

Report

None to date



Pavement milling machines in operation

Schedule: June 1981 — September 1982
Funding: TDC — $75,000
Provincial participants — $75,000

Project Number: 4243, 4244
File Number: D-1465-307-6,7
Project Officer: C. Hirou

Highway Pavement Strength Testing Vehicle

Description

The overall objective of this project is to improve existing pavement strength measuring equipment. The development of an instrumented vehicle that will measure and record flexible pavement strength under a standard wheel load at the operational speed of traffic is an item of high priority among highway authorities.

The Benkelman beam test is the most widely used method of measuring the superficial strength of pavement. But the test procedure has several disadvantages: it requires that a truck be stationed for several minutes in traffic lanes and that personnel be present to ensure safe traffic operations. Productivity is low — only about 100 tests are possible daily. Adequate testing is not economically feasible, especially during the critical spring period, so that only limited evaluations of new pavement are possible.

In a previous project researchers analyzed technical needs and studied new technology. The study concluded that recent advances in mini-computer technology and optical measuring techniques make the design of the proposed vehicle feasible.

Progress to May 1982

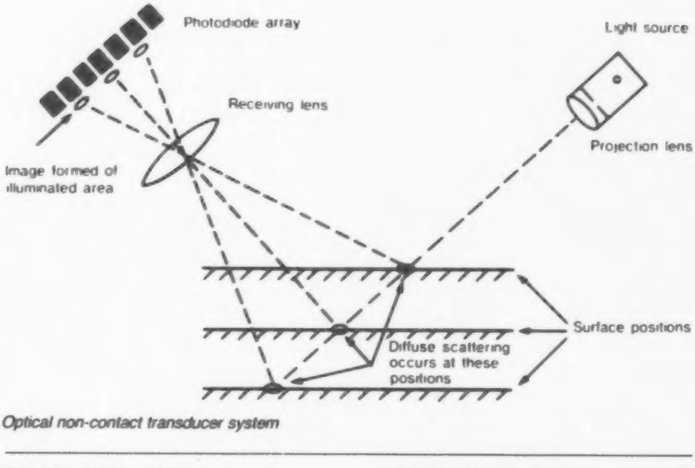
TDC is now defining a five-year program for the development of the vehicle. This program will be based on the recommendations of the Highway Transportation Research and Development Advisory Board with financial support from the Roads and Transportation Association of Canada.

Contractor

To be determined

Report

None to date


Photodiode array
Light source
Receiving lens
Projection lens
Image formed of illuminated area
Surface positions
Diffuse scattering occurs at these positions

Optical non-contact transducer system

Schedule: 1982 — 1987		**Project Number:** 4806
Funding: TDC —	$575,000	**File Number:** D-1465-307-4
RTAC —	$575,000	**Project Officer:** B. Marshall

Compliant Air Bearings to Assist Intermodal Cargo Transfer

Description

The objective of this project is to evaluate the suitability of the Sail Rail technique for the intermodal transfer of cargo on pallets at a freight terminal.

Sail Rail offers the possibility of loading and unloading — easily, rapidly and with a minimum of equipment — charged pallets weighing up to 1500 kg. The technique uses a thin layer of air to reduce the friction between the loaded pallet and the track over which it travels.

Each pallet is supported by two compliant tubular cushions that move along concave tracks built into warehouse floors, trucks, rail cars or loading docks. Small jets in the tracks discharge compressed air that supports tubular cushions or shoes on the bottom of the pallet and permits the load to glide easily and in a controlled manner.

In this project, researchers experimented with various modifications to the air supply holes in an attempt to maximize the lift so as to reduce energy consumption.

Progress to May 1982

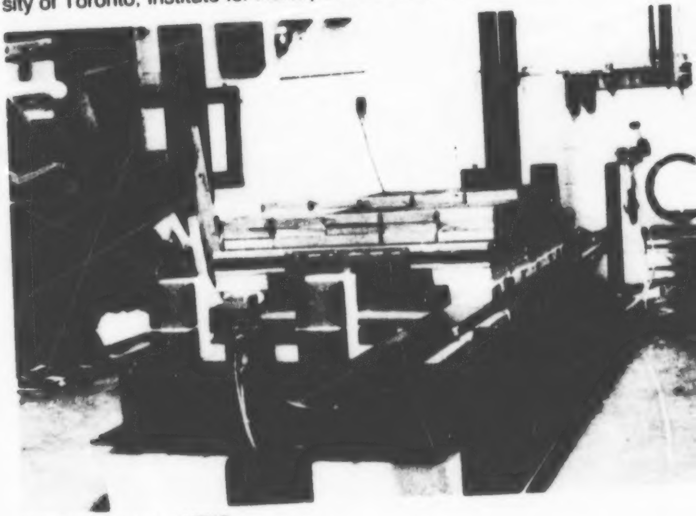
A test-rig was constructed and dynamic tests were conducted using a towed model. There has been some difficulty in obtaining repeatable results from these tests. Current experimental work addresses the effect of the stiffness of the compliant shoe cover material on performance.

Contractor

University of Toronto, Institute for Aerospace Studies, Toronto, Ontario

Report

TP 2817, Research on the Sail Rail Compliant Surface Air Bearing, University of Toronto, Institute for Aerospace Studies, January 1981.



Sail Rail under test at UTIAS

Schedule: March 1981 — July 1982
Funding: TDC — $56,000
DSS — $21,000

Project Number: 4054, 4112
File Number: D-1465-310
Project Officer: J. Laframboise

Innovative Urban Transit Technology

The thrust of TDC's surface transportation research projects is directed generally toward developments that enhance operating efficiency or economic benefits. TDC also recognizes the need for innovative designs and technology that could result in minor system improvements and that have the potential for immediate deployment. Such developments often provide unexpectedly large benefits in terms of passenger satisfaction and operating economies.

The projects presented in this section include:

The design and construction of a **Lightweight Bogie for Intermediate Capacity Transit Systems**.

Development of a Commercial Frequency Linear Induction Motor: a low-cost, rugged LIM powered by commercial 60 Hz power.

Feasibility Study of an Intermodal Shuttle Service: a site-specific study of an intermodal transfer service.

Non-Petroleum Energy Sources for Urban Transit: a study to determine specific areas for development of non-petroleum vehicles.

SSTOP Program Enhancements: development of this traffic management tool to increase road capacity and improve traffic flow.

Innovative Paratransit Vehicle Development: a vehicle that would overcome many of the shortcomings found in regular automobiles currently used in taxi service.

Lightweight Bogie for Intermediate Capacity Transit Systems

Description

The objective of this project is to improve intermediate capacity transit systems through the design, manufacture and evaluation of two motorized, steel wheel-on-rail bogies for application in a light rail system.

Previous work on the project evaluated bogie designs with potential for reducing capital and operating costs of an intermediate capacity rail transit system. The technical characteristics were evaluated using a mathematical model. Cost advantages of the bogie were quantified in comparison with existing bogie designs. Preliminary work on a dynamic model was started, as was preliminary design of the frame, and the bogie and body-shell interface.

Work in the current phase of the project includes manufacture and static tests of the frame, selection of instrumentation and development of a dynamic model. This model will be used to evaluate the bogie's stability and curving performance.

Successful completion of this phase will be followed by:

- fatigue tests to determine modifications with a view to finalizing frame plans;
- construction of two bogies in accordance with detailed plans, followed by assembly and installation;
- factory and field trials for performance measurement of the prototype bogies under service operating conditions.

Progress to May 1982

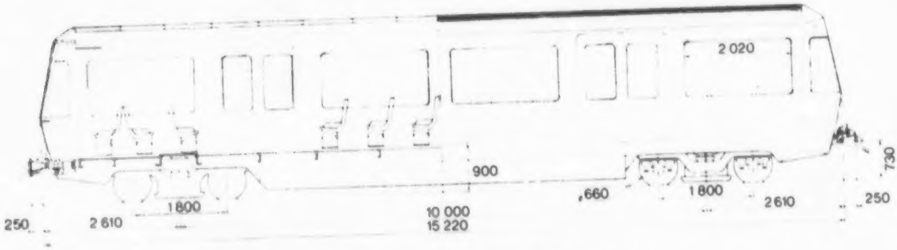
Detailed plans for the truck components have been completed and most components have been manufactured. Assembly of the first truck frame is expected in October 1982.

Contractor

Bombardier Inc., Montreal, Quebec

Report

None to date



Dimensional drawing of intermediate capacity transit vehicle, which would benefit from development of a smaller bogie

Schedule: March 1979 — March 1984

Funding: TDC —	$ 540,000
Transports Quebec —	$1,027,000
Bombardier Inc. —	$ 200,000
Total —	$1,767,000

Project Number: 7644
File Number: D-1465-256
Project Officer: M. Audette

Development of a Commercial Frequency Linear Induction Motor

Description

The objective of this project is to develop a low cost, rugged linear induction motor (LIM) propulsion system powered by commercial 60 Hz power.

In the past year TDC conducted a feasibility study of the application of the Urban Transportation Development Corporation's intermediate capacity transit system (ICTS) to intra-airport transportation. (See page 118.) This study compared the operational requirements for an airport people mover with the ICTS performance specifications and, from this comparison, identified potential modifications to the ICTS to better meet the needs of airports. The study concluded that ICTS is suitable for the application and that a considerable cost improvement is achievable if the linear motor could be powered directly from commercial 60 Hz frequency.

UTDC has completed a feasibility study of a fixed frequency, solid-state, phase-delay, voltage controlled LIM. The study results were promising and the current project is aimed at further developing this concept. The project work will cover the initial design phase for a 60 Hz LIM. It will include the design of motor windings with sketches and specifications; the design of a solid-state switch and control interface; and, a detailed plan, including costs, for the development and testing of the motor.

Progress to May 1982

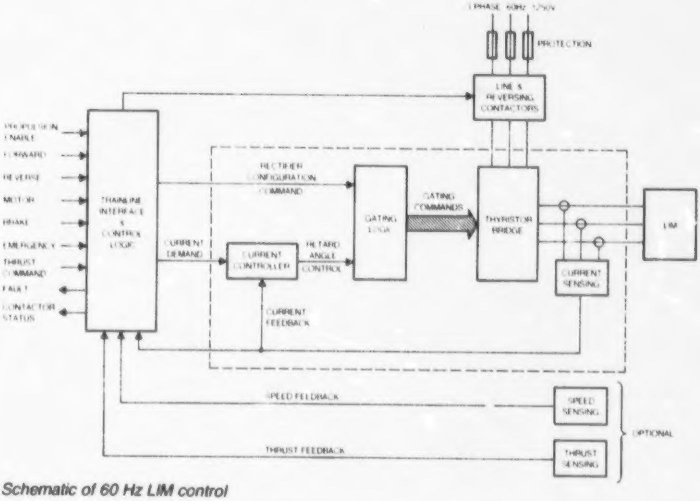
This project has just started.

Contractor

Urban Transportation Development Corporation, Kingston, Ontario

Report

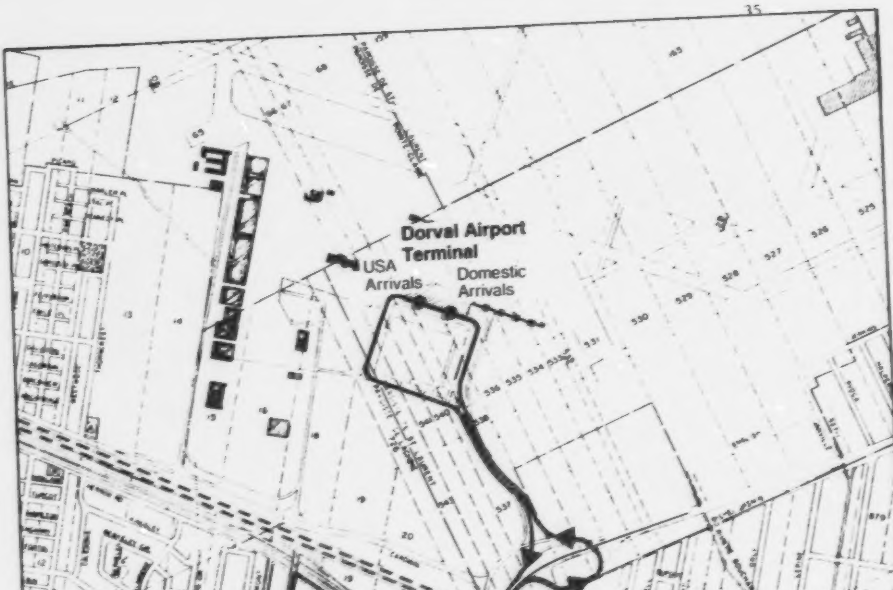
None to date


3 PHASE 60Hz 1250V
PROTECTION
LINE & REVERSING CONTACTORS
PROPULSION ENABLE
FORWARD
REVERSE
MOTOR
BRAKE
EMERGENCY
THRUST COMMAND
FAULT
CONTACTOR STATUS
TRAINLINE INTERFACE & CONTROL LOGIC
RECTIFIER CONFIGURATION COMMAND
CURRENT DEMAND
CURRENT CONTROLLER
RETARD ANGLE CONTROL
GATING LOGIC
GATING COMMANDS
THYRISTOR BRIDGE
LIM
CURRENT SENSING
CURRENT FEEDBACK
SPEED FEEDBACK
SPEED SENSING
THRUST FEEDBACK
THRUST SENSING
OPTIONAL

Schematic of 60 Hz LIM control

Schedule: March 1982 — March 1983
Funding: TDC — $30,000

Project Number: 4596
File Number: D-1465-379
Project Officer: L.A. McCoomb


35
Dorval Airport Terminal
USA Arrivals
Domestic Arrivals
VIA Train Station
Voyageur Bus Terminal

Shuttle route service studied for multimodal connections serving Dorval Airport, Montreal

Feasibility Study of an Intermodal Shuttle Service

Description

The establishment of an integrated transit or multimodal terminal system in Canada would facilitate passenger and freight traffic requiring transfer from one transportation mode to another. Given the large investment involved in such systems, however, the use of the present infrastructure as far as is possible represents an important economic consideration in seeking ways to minimize investment costs.

The objective of this study is to determine the feasibility of establishing a shuttle service to connect the various transportation modes in an urban centre, and to prepare a detailed plan for the implementation of such service, including technological aspects.

Dorval Airport was the specific site selected for the study, since the various transportation operators serving the airport (Voyageur, Murray Hill and MUCTC buses, and the VIA Rail and CP commuter train stations) are all located within a radius of three kilometres.

The study consists of reviewing and analyzing the literature on similar systems; meeting with representatives of the transportation companies to gather data on the users of the various transportation modes; studying the requirements of applicable federal and provincial legislation; and profiling Dorval users so as to determine demand for a shuttle service.

Progress to May 1982

Investigators have determined that some demand for a shuttle service does exist. They predict this demand would rise dramatically if the frequency of the commuter rail service were increased. To quantify the actual demand, it would be necessary to gather information on passenger movements at different boarding points. They also found that the regulations covering shuttle services vary considerably, depending on whether the service is considered part or independent of the public transit network.

Contractor

Econosult Inc., Montreal, Quebec

Report

Draft, Étude de faisabilité de la mise en place d'un service de navette à Dorval, Econosult Inc.

Schedule: February 1982 — August 1982
Funding: TDC — $15,000

Project Number: 4452
File Number: D-1465-352
Project Officer: S. Corbeil

Non-Petroleum Energy Sources for Urban Transit

Description

A considerable amount of attention is now being focused on reducing Canada's dependence on petroleum fuels. Fuel substitution in the transportation sector, a major user of petroleum fuels, is more difficult than in the residential, commercial and industrial sectors. Canadian urban transit systems are particularly dependent on diesel fuel.

The objective of this project was to investigate the availability of alternative technologies to convert public transit systems to non-petroleum energy sources.

Researchers prepared an overview of the potential for substitution of petroleum fuels used by public transit systems. The study describes the characteristics of systems using: electricity (e.g. trolley buses, battery-powered buses, light rapid transit, streetcars); alternative portable fuels such as methanol and ethanol; synthetic fuels and gaseous fuels such as propane, compressed natural gas and liquefied natural gas. The researchers then ranked the various technologies according to their suitability for Canadian application.

The results of this work will guide TDC as to what steps could be taken to encourage the development of energy alternatives for urban transit systems.

Progress to May 1982

This project is complete. It was concluded that there are ways to significantly reduce petroleum fuel consumption by urban transit vehicles. Many, of course, are already in use either in Canada or abroad. Several areas were identified for further development. These include a spark ignition engine for buses; production techniques for alcohol fuels; energy storage devices for trolley and diesel buses; and, improved off-wire capability of trolley buses in terms of range and performance.

Contractor

IBI Group Inc., Toronto, Ontario

Reports

Draft, Non-Petroleum Energy Sources for Urban Transit, summary report, IBI Group Inc.

TP 3684, Non-Petroleum Energy Sources for Urban Transit, final report, IBI Group Inc., May 1982.

Canadian-built trolley in service in Vancouver's transit system

Schedule: September 1981 — May 1982
Funding: Energy R&D Panel — $15,000

Project Number: 446
File Number: D-1450-123
Project Officer: T. Smith

SSTOP Program Enhancements

Description

The objective of this project is to enhance the Signal System Optimization Package (SSTOP), a computer program designed to help traffic engineers increase road capacity and traffic flow in urban areas by automatic signal timing.

Developed in Canada through TDC grants, SSTOP is based on the Real Time Optimization Program designed by the Metropolitan Toronto Traffic Control Centre. In an earlier TDC project, SSTOP was evaluated in Quebec City, Montreal and Cambridge, Ontario. These tests revealed certain shortcomings in the program, which were subsequently corrected.

Despite its sound theory and custom design for Canadian application, SSTOP has not found widespread use. While essentially a means to optimize traffic signal timing, SSTOP also has the potential to evaluate costs and benefits of signal system improvements. This project is aimed at devising new logics that will enhance the program's capabilities as a traffic control and evaluation tool.

Progress to May 1982

Researchers have modified the program to increase its accuracy and developed new logics, including one which provides fuel consumption estimates. The logics have been integrated into SSTOP and tested. The refinements promise to increase the program's serviceability. The project steering committee is reviewing the final report.

Contractor

DeLCan Ltd., Ottawa, Ontario

Report

Draft, SSTOP Program Enhancements, 3 volumes, DeLCan Ltd.

Schedule: January 1982 — August 1982
Funding: TDC — $30,000

Project Number: 4579
File Number: D-1465-281-1
Project Officer: S. Corbeil

Innovative Paratransit Vehicle Development

Description

The long term objective of this work is to develop a passenger vehicle particularly suitable to paratransit operations in urban and rural areas. These operations meet transportation needs that fall outside the purview of normal inter- or intracity scheduled transit service. Typical paratransit operations are taxis and airport access and seasonal resort access systems.

Previous work on this project saw the design and fabrication of a full mock-up model of an innovative taxi based on a design by Guillon, Smith, Marquart & Associates (GSM) of Montreal. An experimental prototype was licensed in September 1980 for operation on public roads. Made of standard parts and production materials whenever possible, the vehicle incorporates rugged, proven North American running gear into a body not much longer than current sub-compacts but with entry ease, interior space and visibility designed especially for paratransit operations. The design features bolt-on, resilient and non-corroding urethane bumpers and side panels.

In the latest phase, the vehicle underwent extensive tests so as to:

- define basic performance criteria,
- identify structural shortcomings,
- assess passenger acceptability, and
- evaluate suitability for paratransit application.

Progress to May 1982

Since fall 1980, the vehicle has been exhibited at transportation shows across Canada and the U.S. It has also been driven extensively in and around Montreal. The vehicle has been well received by both operators and the user public. GSM is looking into possibilities for quantity production.

Contractor

Guillon, Smith, Marquart & Associates, Montreal, Quebec

Report

TP 2688, Innovative Paratransit Vehicle — The GSM Taxi, Guillon, Smith, Marquart & Associates, August 1980.

GSM taxi

Schedule: March 1980 — December 1981
Funding: TDC — $15,000

Project Number: 4262
File Number: D-1465-291-1
Project Officer: M. Audette

Tracked Levitated Vehicle Technology

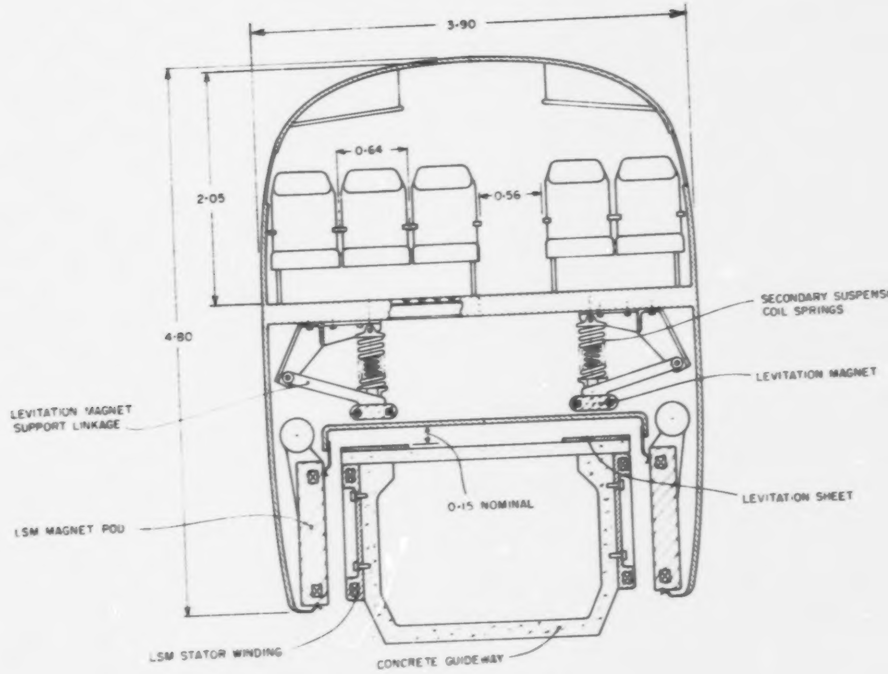
Lightweight vehicles with non-contact suspension, guidance and propulsion systems possess attributes that make them ideal candidates for future intercity transportation systems. Their higher operating speed and the concern over the accelerated wear and tear experienced with steel wheel-on-rail systems operating above 200 km/h have prompted a number of advanced industrialized countries to look at tracked, magnetically levitated (Maglev) passenger transportation systems.

In 1971, TDC initiated a long range research and development program in the field of magnetically levitated transportation. The overall objective of the **Maglev Development Program** can be described as the operational deployment in Canada of a high speed, electrodynamic, magnetically levitated, guided ground transportation system propelled by a linear synchronous motor. The time frame during which this objective will be achieved depends upon many factors, of which technical progress is but one.

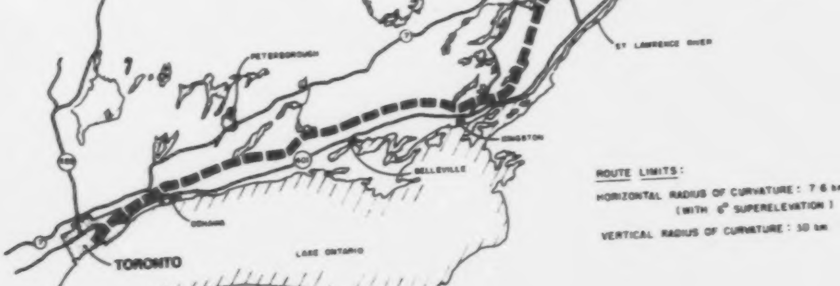
Recognizing that it may be a long time, if ever, before an operational Maglev system is deployed in Canada, one short-term goal of Canadian research is to establish a nucleus of professionals who understand the fundamentals of magnetic levitation and linear motor technology.

Under the Maglev program, TDC and the National Research Council have a cooperative agreement to establish a Canadian technical capability in Maglev technology. Current work in the program is aimed at the design of a prototype lightweight superconducting magnet commensurate with the general requirements of the Canadian Maglev system. This work is being carried out with the participation of industry and through an information exchange arrangement with Japan.

The Maglev team keeps current with developments worldwide. **Assessment of Tracked Levitated Vehicles** explores the potential of the West German ferromagnetic Maglev system for Canadian use.


3·90
0·64
0·56
2·05
4·80
SECONDARY SUSPENSI
COIL SPRINGS
LEVITATION MAGNET
LEVITATION MAGNET SUPPORT LINKAGE
0·15 NOMINAL
LEVITATION SHEET
LSM MAGNET POD
LSM STATOR WINDING
CONCRETE GUIDEWAY

Cross-section of Maglev vehicle (dimensions in metres)


QUEBEC
OTTAWA RIVER
ALGONQUIN PARK
HAWKESBURY
MIRABEL AIRPORT
OTTAWA
MONT
ONTARIO
QUEBEC
U S A
ST LAWRENCE RIVER
PETERBOROUGH
KINGSTON
BELLEVILLE
OSHAWA
LAKE ONTARIO
TORONTO
ROUTE LIMITS:
HORIZONTAL RADIUS OF CURVATURE: 7.6
(WITH 6° SUPERELEVATION)
VERTICAL RADIUS OF CURVATURE: 10 km

Proposed route for Maglev service

Maglev Development Program

Description

The purpose of this research program is to examine technological designs for a tracked, magnetically levitated (Maglev) transportation system. Maglev is being considered as a possible long-term alternative intercity passenger transportation system in the densely populated Toronto-Ottawa-Montreal corridor. Non-contact magnetically levitated transportation systems, which do not rely on petroleum fuel, travel at speeds up to 480 km/h. Non-contact suspension, guidance and propulsion avoid the costly maintenance required for conventional high speed railway trains. They provide increased capacity and frequency of service and, for trips of less than 800 km, their predicted door-to-door travel time is shorter than that of conventional jet aircraft.

The Maglev development program is a long-range, exploratory research effort. The critical components are the superconducting magnets for electrodynamic levitation and the linear synchronous motor for propulsion. Initial vehicle design and system integration work has been completed, based upon Maglev transportation concepts developed by the Canadian Maglev Group. This interdisciplinary team of scientists and researchers from Queen's University, the University of Toronto and McGill University work under the aegis of the Canadian Institute of Guided Ground Transport (CIGGT).

The National Research Council (NRC) appraised the Maglev design concepts for TDC and produced the final integrated system and vehicle concept. A site-specific, techno-economic study concluded that a Maglev system would provide substantial savings in operational costs as compared to the conventional intercity transport modes. It also indicated that a key element in the proposed Canadian Maglev concept, the lightweight superconducting magnet, is in need of further development.

The objective of the current project is to design a prototype lightweight superconducting magnet commensurate with the general requirements of the Canadian Maglev system. The work will be carried out by a design team with representatives from NRC, CIGGT and industry. The design will be sufficiently advanced so as to permit construction of a prototype.

Progress to May 1982

The first participant from industry, CTF Systems Inc., has been contracted through NRC for initial design work.

Contractor

National Research Council, Ottawa, Ontario

Subcontractor

CTF Systems Inc., Vancouver, British Columbia

Report

None to date

Schedule: March 1982 — March 1984
Funding: TDC — $250,000

Project Number: 4541
File Number: D-1465-269
Project Officer: M. Audette

Assessment of Tracked Levitated Vehicles

Description

The aim of this project is to ensure that full advantage is taken of advanced, non-contact vehicle suspension technology to benefit the Canadian traveller.

For some years now, the Federal Republic of Germany has been pursuing the development of an advanced transportation system. This work has culminated in the development of the Transrapid EMS. Canada has been monitoring this work so as to compare the potential of the German ferromagnetic Maglev technology with that of Canadian superconducting technology. Now, thanks to an agreement between Canada and the Federal Republic of Germany for scientific and technical cooperation, information on the German technology is being made available to Canada for an assessment of its application to Canadian needs.

TDC is sponsoring a comparative assessment of the German system and more conventional technology on a link between Ottawa and Montreal, via Mirabel. The comparison criteria will be based on explicit service and hardware requirements for the advanced and conventional technologies.

The expected benefits of this project will be a better understanding of the ferromagnetic technology, its potential, associated technical issues and probable costs. Furthermore, it will establish a nucleus of Canadian specialists with an in-depth understanding of this new technology.

Progress to May 1982

Canatrans Inc. and Transrapid International of Germany are developing a study plan.

Contractor

Canatrans Inc., Montreal, Quebec

Report

Draft, Study Design for the Comparative Assessment of the Transrapid System and an Advanced Railway System in High Speed Service betwee Montreal, Mirabel and Ottawa, Canatrans Inc.

Transrapid EMS. West Germany's advanced transportation system

Schedule: November 1981 — July 1982
Funding: TDC — $15,000

Project Number: 4459
File Number: D-1465-356
Project Officer: M. Audette

Off-Road Vehicles

Off-road vehicles are those vehicles operable in areas inaccessible to standard cars and trucks. They are used in civil engineering, forestry and general transport tasks associated with exploration and remote construction work.

The general objective of the TDC development program is to improve off-road transportation so as to reduce the scale of investment required for access to the Canadian hinterland. Current projects are:

Arctic Snowmobile Technical Study: an investigation into the technical limitations of snowmobiles now used in the Arctic, preparatory to the development of specifications for a vehicle more specifically suited to operations in the far north.

Vehicular Movement Over Ice Roads on Lakes and Rivers: a study of the characteristics of ice roads.

Aerobac Design Study: the development of a hybrid vehicle using air cushion technology and caterpillar traction.

Arctic Snowmobile Technical Study

Description

The snowmobile has become an integral part of the transportation system in Canada's Arctic regions. It provides personal transportation in a form compatible with the lifestyle of the local population, and has largely displaced the traditional dog sled. The snowmobile is essential for hunting and trapping, on which much of the northern economy is based, and is the principal means of short distance travel.

Over the years the snowmobile has evolved into a primarily recreational vehicle for the southern population and now may not be sufficiently rugged or reliable for the Arctic environment. The service life of a snowmobile in the Arctic can be as short as one year.

The objective of this project is to identify the technical limitations of current snowmobiles and to prepare specifications for a snowmobile to be developed specifically for the Arctic.

The results of this project could see the development of an improved snowmobile offering greater economy and reliability for personal transportation in the Canadian north.

Progress to May 1982

This project is complete. The study report identifies some design changes whereby the recreational snowmobile could be made more suitable for utility service. The market for utility vehicles is small however and the cost effectiveness of such a vehicle is doubtful unless local assembly is possible.

Contractor

Peter Poole Consulting Services Inc., Dunham, Quebec

Report

Draft, Snowmobiles as Utility Vehicles in the Arctic: Current Performance and Prospects for Improvement, Peter Poole Consulting Services Inc.

Schedule: July 1981 — March 1982
Funding: TDC — $40,000

Project Number: 4281
File Number: D-1465-320-1
Project Officer: J. Laframboise

Vehicular Movement Over Ice Roads on Lakes and Rivers

Description

The objective of this project is to develop a statement of research requirements respecting the mechanics of ice roads over lakes and rivers. Project tasks include a literature survey and discussions with regulatory authorities and builders, designers and users of ice roads.

At present various authorities set quite different load and speed regulations for a given thickness of ice, based mostly on experience. The results of this project should enable better correlation between regulations governing similar winter roads and improve both the safety and efficiency of winter transport operations.

Progress to May 1982

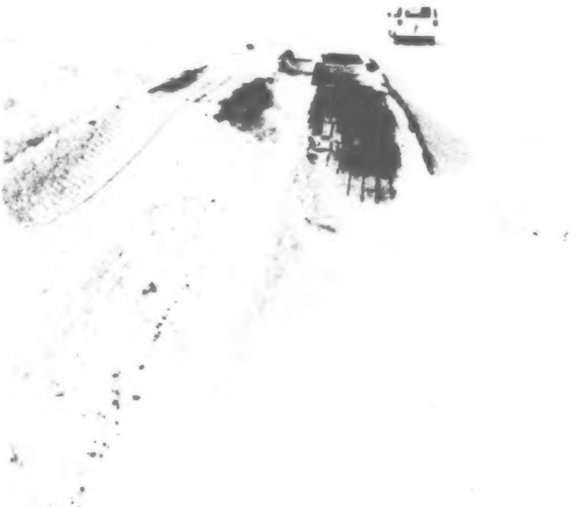
This project is complete. Several areas were identified for theoretical and experimental research. These include: ice properties and measurement techniques, static bearing capacity of ice roads and dynamic loads on ice roads.

Contractor

University of Manitoba, Winnipeg, Manitoba

Report

Draft, Research into Transport Aspects of Ice Sheets, University of Manitoba.



Ice road through pressure ridge on Lake Athabaska

Schedule: January 1982 — July 1982
Funding: TDC — $15,000

Project Number: 4479
File Number: D-1465-360
Project Officer: J. Laframboise

Aerobac Design Study

Description

The Aerobac is an off-road, amphibious vehicle that integrates an air cushion lift system with caterpillar traction. The objective of this project was to verify the feasibility of the Aerobac concept and to define the conditions for the development and evaluation of a prototype unit.

The contractor prepared a specification for the vehicle, defining the performance required of the lift system, power and traction systems and the vehicle structure. A preliminary cost breakdown for the construction and evaluation of a prototype unit was also prepared.

Progress to May 1982

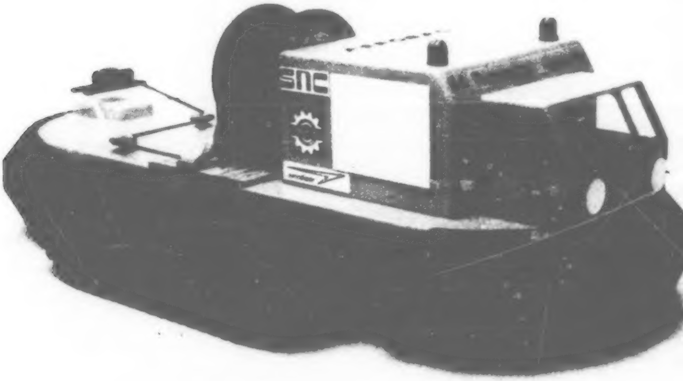
This project is complete. The concept for an Aerobac vehicle with a payload of 7000 kg has been defined. This vehicle is designed to transport light construction material over difficult terrain.

Contractor

SNC Inc., Montreal, Quebec

Reports

TP 3508E, Aerobac AB-7: Technical Feasibility Study, summary report, SNC Inc., March 1982.
TP 3507F, Aérobac AB-7: étude de faisabilité technique, rapport final, SNC Inc., mars 1982.



Aerobac AB-7

Schedule: September 1981 — March 1982
Funding: TDC — $30,800
DSS — $64,000

Project Number: 4414
File Number: D-1465-258
Project Officer: J. Laframboise

Alternative Energy Sources

The National Energy Program, announced in October 1980, outlines the manner in which the Government of Canada intends to achieve its objectives in the energy field. Of prime interest to the transportation sector is the goal of maintaining oil consumption essentially constant over the next decade in spite of the expected increase in demand for transportation services. Oil consumption for transportation is currently 865,000 barrels/day. Transport Canada forecasts show that, by 1990, consumption will rise to 1,110,000 barrels/day unless conservation and substitution measures are introduced.

Several projects relate to the use of propane fuels for road vehicles. These include:

Development of Propane-Fueled Vehicles: the modification of current gasoline engines to run effectively on liquid propane fuel. An evaluation of the technical, operational and economic aspects of using liquid propane as fuel in the engines of passenger cars and small commercial vehicles forms the basis of this project. Another project, **Optimization of Propane Engines**, looks beyond simple carburetor changes to define several areas of research that could optimize the efficiency of vehicles operating on propane. Yet a third project in this area deals with **Propane/Diesel Engine Development**.

Another group of projects addresses hybrid technology and innovative engine design:

Hybrid Road Vehicle Development: a look at electric/gasoline engine combinations, which offer estimated gasoline fuel savings of up to 60 per cent.

Diesel/Flywheel Hybrid Drive Train: flywheel technology holds the promise of reducing fuel consumption through regeneration of braking energy. This project investigates the application of flywheels to city buses.

DISC Engine Feasibility Study: the development of a direct-injection, stratified-charge engine capable of operation on wide-cut fuels and alcohols.

Batteries play an important role in electric vehicle technology. Recognizing this, TDC is supporting three projects in this area:

Nickel-Zinc Batteries for Road Vehicle Propulsion

Vehicle Battery Research and Development in Canada

Advanced Battery Charger for Electric Vehicles

Development of Propane-Fueled Vehicles

Description

Propane is a by-product of the petroleum refining process and of the "scrubbing" of natural gas. In 1979, Canada produced approximately 130 thousand barrels of propane daily, of which only about one half was required domestically and this for non-transport applications. The balance was exported. This surplus of propane gas is projected to continue in the foreseeable future.

Propane is used as a vehicle fuel. Gasoline-powered vehicles can run effectively on propane once they have undergone a few changes, involving primarily the addition of a storage tank and modifications to the carburetor system.

The objectives of this project are to study the technical, operational and economic aspects of propane-fueled engines in passenger automobiles and small commercial vehicles so as to increase the use of propane in the transportation field and to develop a method for assembly line conversion of automotive vehicles to run on propane, thereby reducing the cost of propane conversion.

To achieve these objectives, researchers designed propane fuel systems adaptable to assembly line installation for 8 cylinder (5.2 ℓ), 6 cylinder (3.7 ℓ), and 4 cylinder (2.2 ℓ) engines. The systems incorporate engine changes required to ensure durability, but do not include such changes as a higher compression ratio, which would be required to optimize fuel consumption and performance.

Fourteen vehicles were manufactured in accordance with normal production procedures and subsequently converted to propane fuel operation. The vehicles include commuter vans, panel trucks, pick-up trucks, conventional taxis and front wheel drive cars.

A test program is currently underway to determine the operating efficiences of the vehicles and to produce quantitative data on the cost of operating and maintaining such vehicles. This program shall include a one-year operational demonstration of the vehicles in different areas of Canada.

Progress to May 1982

The fourteen propane-fueled vehicles are just completing the one-year operational demonstration program. To date they have been well received and have suffered no major problems. Energy savings have been running between 10 and 15 per cent for the various vehicles. These encouraging results have prompted TDC to plan a study to optimize the propane-fueled engine.

Contractor

Chrysler Canada Ltd., Windsor, Ontario

Report

None to date

Schedule: March 1981 — December 1982
Funding: TDC — $ 25,000
Energy R&D Panel — $150,000

Project Number: 4294
File Number: D-1465-326
Project Officer: J.H. Morgan

Optimization of Propane Engines

Description

This project constitutes the definition phase of an R&D program to optimize the efficiency of internal combustion engines of automobiles and light-duty commercial vehicles operating on propane fuel.

One of the promising ways to reduce the consumption of gasoline and diesel oil in Canadian transportation is the wider use of propane. In order to make conversion to propane attractive, it is essential that the propane-fueled vehicle be as efficient as possible. A comprehensive research, development and implementation program will address this issue.

The definition phase will provide a sound basis for determining the appropriate motor vehicle applications for propane, considering its expected availability in comparison with gasoline, diesel, and other fuels. Improvements to component manufacture and integration with conventional vehicles at assembly will be considered, in addition to improvements to engine and fuel systems for better efficiency, range, performance, and other consumer appeal features.

Progress to May 1982

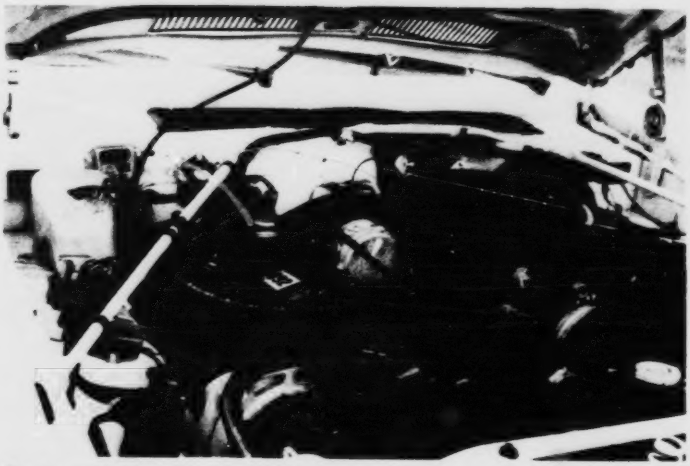
This project has just started.

Contractor

Chrysler Canada Ltd., Windsor, Ontario

Report

None to date



Chrysler engine fitted with modified carburetor

Schedule: April 1982 — March 1983
Funding: Energy R&D Panel — $118,000

Project Number: 4552
File Number: D-1450-127
Project Officer: J.H. Morgan

Propane/Diesel Engine Development

Description

The objective of this project is to develop a Canadian system for the conversion of diesel engines to dual fuel (propane/diesel) operation so as to encourage the partial substitution of propane for diesel fuel in mobile and stationary diesel engines.

The contractor will develop components for injecting a propane/diesel oil mixture into diesel engines; test the equipment under laboratory conditions on 200 and 400 horsepower engines; and, conduct field trials on eight mobile and two stationary diesel engines ranging in size from 200 to 400 horsepower. The test program for the field trials will include instrumentation required to analyze data such as:

- vehicle driveability under normal, extended and extreme driving cycles;
- fuel economy in each portion of the driving cycles;
- vehicle range or load encumbrances due to propane addition;
- safety experience, particularly at maximum power and at refuelling;
- effect of ambient temperature, winter season start-up in particular;
- altitude response;
- effect of propane on engine power (horsepower, acceleration);
- mechanical effects on the drive train;
- wear, as measured by laboratory analysis of lubricating oil;
- injector fouling and other factors normally associated with diesel engines.

Experiments have indicated that propane could replace as much as 30 per cent of the fuel used in diesel engines, with an attendant improvement in fuel efficiency and reduction in overall emission levels.

Progress to May 1982

This project has just started.

Contractor

Space Fuel Gas Products Ltd., Calgary, Alberta

Report

None to date

Schedule: March 1982 — March 1984
Funding: Energy R&D Panel — $257,000
Project Number: 4480
File Number: D-1450-124
Project Officer: J.H. Morgan

Hybrid Road Vehicle Development

Description

The objective of these studies is to design, construct and evaluate two hybrid gasoline/electric vehicles, one in a series drive configuration and the other in a parallel configuration. Estimated petroleum fuel savings of hybrid vehicles compared to conventional vehicles range as high as 60%.

These studies evolved from TDC's electric vehicle evaluation and development program, underway since 1979. TDC has concluded that although electric vehicles will play a useful role in displacing oil-based fuels for specific applications, the hybrid vehicle has greater potential in Canada. For this reason TDC is shifting its R&D focus from the pure electric vehicle to the hybrid vehicle.

Two Marathon C-360 electric vans will be converted to hybrid configuration. A Briggs & Stratton, 18 horsepower, two-cylinder air-cooled gasoline engine will be the petroleum-based power plant for each vehicle. The series hybrid vehicle will use 120 V, 60 Hz generator and rectifier to provide the d.c. output required. A control system will be developed that will permit varying between battery-only operation and a combined battery-generator operation. The parallel hybrid vehicle will be capable of operation on either the gasoline engine or the d.c. traction engine alone, or on both simultaneously.

Progress to May 1982

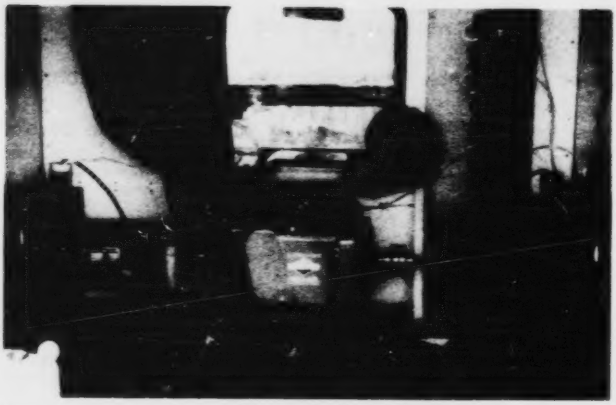
The parallel hybrid vehicle has been constructed and a series of tests conducted at Transport Canada's Motor Vehicle Test Centre. These tests provided data on fuel consumption and performance. Some modifications to the vehicle are planned, followed by further tests. The series hybrid vehicle is being assembled.

Contractor

Marathon Electric Vehicle Inc., Montreal, Quebec

Report

Draft, The Marathon C-360 Parallel Hybrid Vehicle, Marathon Electric Vehicle Inc.



Power source for series hybrid vehicle consisting of a gasoline engine and two alternators

---

Schedule: July 1981 — September 1982
Funding: TDC — $104,000

Project Number: 4515, 4402
File Number: D-1465-145-3/2
Project Officer: J.H. Morgan

Diesel/Flywheel Hybrid Drive Train

Description

The availability of new high tensile strength steels and fibres makes it possible to build flywheels with a high energy storage capacity (power density), in fact superior to that of any battery, present or proposed. When installed in an evacuated housing (to minimize windage losses), a flywheel rotating at high speed becomes a practical energy storage device. It can be used to store vehicle braking energy and supply it for peak power drains during acceleration, thus permitting the use of smaller engines and improving energy efficiency.

A TDC study commissioned in 1976 estimated that diesel engine/flywheel hybrid drive vehicles can consume up to 50 per cent less energy than conventional vehicles. The study recommended the transit bus as the first application for a flywheel energy storage device. The current project aims to determine, through experimental work, whether the theoretically predicted energy saving of up to 50 per cent can be achieved in practice.

The work entails designing, constructing and testing a diesel/flywheel hybrid drive train with a continuously variable transmission (CVT). The drive train will have power transmission characteristics suitable for a transit bus, although the size and weight of the components will not necessarily be appropriate for a bus. A special stationary rig was constructed for testing of the drive train at the Urban Transportation Development Corporation.

Researchers will conduct extensive tests of the assembled drive train under simulated driving conditions. The findings will provide a basis for the comparison of the hybrid drive train with other propulsion alternatives.

Progress to May 1982

This project is complete. A diesel engine, flywheel and CVT were installed in a dynamometer test-rig for operation through typical bus operating route cycles. A HP 1000 computer was used to control and monitor the performance of the components. Fuel consumption of the hybrid drive train was then compared with that of the conventional drive train.

The work demonstrated that while the hybrid drive train concept is feasible, its fuel efficiency and controllability would substantially improve if it were equipped with a specially configured CVT.

Contractor

Urban Transportation Development Corporation, Kingston, Ontario

Report

TP 3620, Flywheel Experimental Program: Development of a Hybrid Drive Line, 2 volumes, Urban Transportation Development Corporation, April 1982.

Schedule: January 1978 — March 1982

Funding: TDC —	$ 444,000
Energy R&D Panel —	$ 560,000
UTDC —	$ 325,000
Total —	$1,329,000

Project Number: 7512, 7583
File Number: D-1465-246
Project Officer: C.A. Versailles

DISC Engine Feasibility Study

Description

The objective of this project is to reduce Canada's dependence on oil-based fuels by encouraging the development of a direct injection stratified charge (DISC) engine modification package that will permit operating vehicles on wide-cut fuels and alcohols. Its specific objective is to define the theoretical and economic feasibility of the application of DISC technology to a Ford 300, six-cylinder engine.

DISC technology has the potential to improve fuel efficiency under urban driving and cold weather conditions by up to 30 per cent by providing a leaner and more efficient mix of air and fuel, controlled flame propagation and more precise ignition timing. Further energy savings can be derived from the DISC engine's capability of operating on wide-cut fuels, produced by a refinery process that increases the amount of fuel recoverable from a given quantity of crude oil.

The contractor will define the design changes required to the Ford 300 gasoline engine and its components and prepare design data in sufficient detail to establish thermodynamic feasibility and provide cost estimates. A theoretical review of the engine performance will also be undertaken, followed by an examination of the costs and benefits of DISC conversion.

With a modified fuel injection system, the engine should also be able to operate on methanol and ethanol.

Progress to May 1982

Several DISC modification options for the Ford 300 engine have been developed. They are being evaluated so as to determine the most practical among them.

Contractor

SNC Inc., Montreal, Quebec

Subcontractors

Ontario Research Foundation, Toronto, Ontario
Purolator Canada Ltd. (Eastern Canada Division), Montreal, Quebec
Texaco Research Inc., Beacon, New York

Report

None to date

Schedule: February 1982 — December 1982
Funding: Energy R&D Panel — $132,000

Project Number: 4517
File Number: D-1465-365
Project Officer: J.H. Morgan

Nickel-Zinc Batteries for Road Vehicle Propulsion

Description

Electric and hybrid vehicles have long-term potential for replacing large numbers of small commercial vans and private automobiles in Canada. Major impediments to the successful development of electric and hybrid vehicles are the limited performance and the high cost of existing lead-acid propulsion batteries.

The nickel-zinc battery promises to at least triple the specific power and energy storage density of existing batteries. It is, however, expensive to produce and has an unacceptably short life cycle for transportation applications. In this project, researchers aim to improve the nickel-zinc battery by:

- increasing its life cycle through improvements to the negative electrode, thereby lowering energy costs, and
- developing zinc alloys in the negative grid that are suitable for high speed fabrication, thus helping to reduce battery production costs.

This work is expected to lead to more effective and cost-competitive electric and hybrid vehicles. It could also have important implications for starting batteries for conventional vehicles as well as on storage batteries used for various purposes.

Progress to May 1982

A literature search relating mainly to the formation of titanium oxide films on zinc and to the stability of those films in alkaline solutions has been completed. Cells for the electrochemical tests have been designed and fabricated. Work is underway to develop a reproducible test procedure.

Contractor

Cominco Ltd., Toronto, Ontario

Report

None to date

Schedule: March 1981 — December 1982

Funding: TDC —	$ 15,000
EMR —	$ 15,000
DND —	$ 15,000
DSS —	$ 95,000
Total —	$140,000

Project Number: 4322
File Number: D-1465-336
Project Officer: J.H. Morgan

Vehicle Battery Research and Development in Canada

Description

The object of this project was to analyze the current status of electric vehicle battery technology in Canada so as to identify possible areas for federal government support for research and development.

The contractor reviewed, through a literature search, the state of the art in the electrically reversible (chargeable) battery, which in vehicles is used predominantly for starting, lighting and ignition. R&D activities in Canada were identified and evaluated in comparison with those underway around the world through discussions with battery manufacturers, research organizations and federal and provincial government departments.

Progress to May 1982

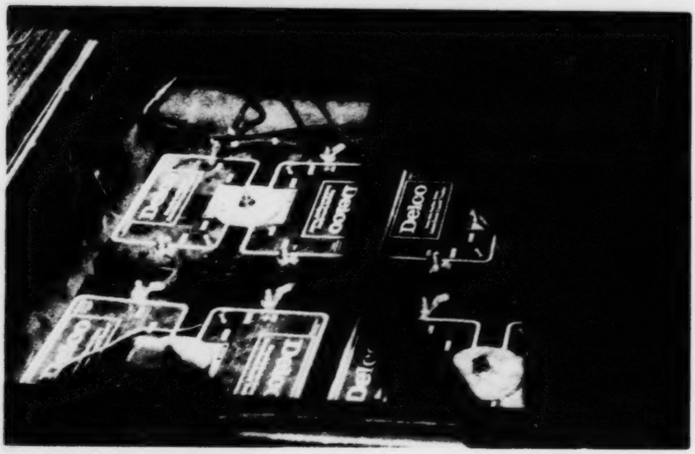
This project is complete. The study report concludes that the present and possible future levels of production of electricity in Canada are adequate to meet the energy needs defined by the National Energy Program for oil substitution. The production capacity in Canada and the large contribution to be made by hydro-electric power are such that there is no urgent need for the development of electric storage batteries for load-levelling by Canadian utilities. The principal R&D opportunity for Canada was shown to lie in the current, expanding market of electric storage batteries for transport vehicles -- both the existing types of starting, lighting and ignition battery and the high performance battery for electric vehicles.

Contractor

R.F. Webb Corporation Ltd., Ottawa, Ontario

Report

TP 3110, Battery Research and Development in Canada, R.F. Webb Corporation Ltd., June 1981.



Schedule: March 1981 — March 1982
Funding: TDC — $15,000

Project Number: 4406
File Number: D-1465-342
Project Officer: J.H. Morgan

Advanced Battery Charger for Electric Vehicles

Description

The objective of this project is to develop an efficient, lightweight, microprocessor-controlled battery charger for electric vehicles.

Existing battery chargers are too heavy or bulky to be carried aboard vehicles; nor do they charge to maximum capacity of a given battery, resulting in the premature failure of expensive cells. Furthermore, existing chargers, which are of the transformer/rectifier type, impose a heavy inductive load on the power utility.

While the low power factor has not yet proved to be a major problem, it will become so once a greater number of electric vehicles are in service, resulting in increased demand for charging at the same time of day.

Researchers will develop a specification for an advanced battery charger, evaluate new circuit designs, design and test an engineering prototype and, finally, manufacture three units for in-service testing.

Progress to May 1982

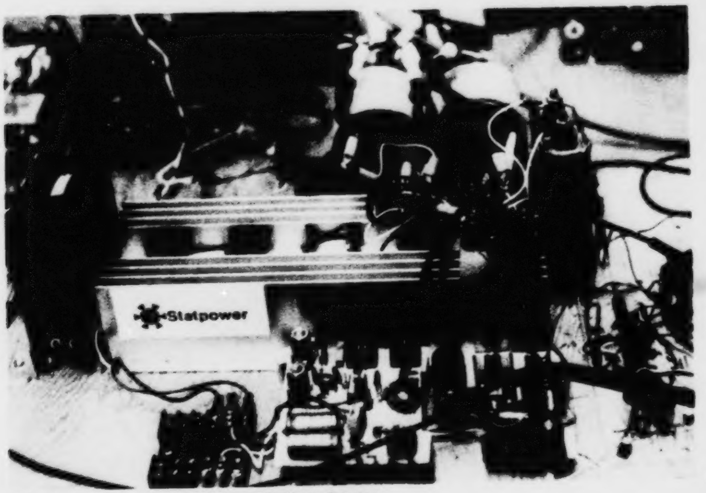
A breadboard of a promising circuit design has been constructed and tests are underway.

Contractor

A.C. Statpower Inc., Vancouver, British Columbia

Report

None to date



Breadboard assembly of advanced battery charger

Schedule: July 1981 — November 1982
Funding: TDC — $15,000
DSS — $34,000

Project Number: 4442
File Number: D-1465-351
Project Officer: J.H. Morgan

Transportation for the Mobility Handicapped

Accessible transportation is the key to independence, self-reliance and full participation in society for Canada's one million disabled citizens. Full access to transportation services would provide the opportunities for employment and participation in social and recreational activities enjoyed by the able-bodied.

Many of Canada's transportation services fall under federal jurisdiction. For this reason, TDC supports developments in technology that improve accessibility to all transportation modes — air, rail, marine and surface.

Several innovative designs sponsored by TDC, such as the **Multimodal Wheelchair Securement/Passenger Restraint System**, are ready to be deployed in the nation's transportation systems. Others are still in the formative stages. These include:

Barrier-Free Terminals and Transfer Facilities: the development of a self-propelled transfer vehicle for use in terminals.

Quick-Release Hand Controls for Automobiles: these controls would make rental cars available to disabled people.

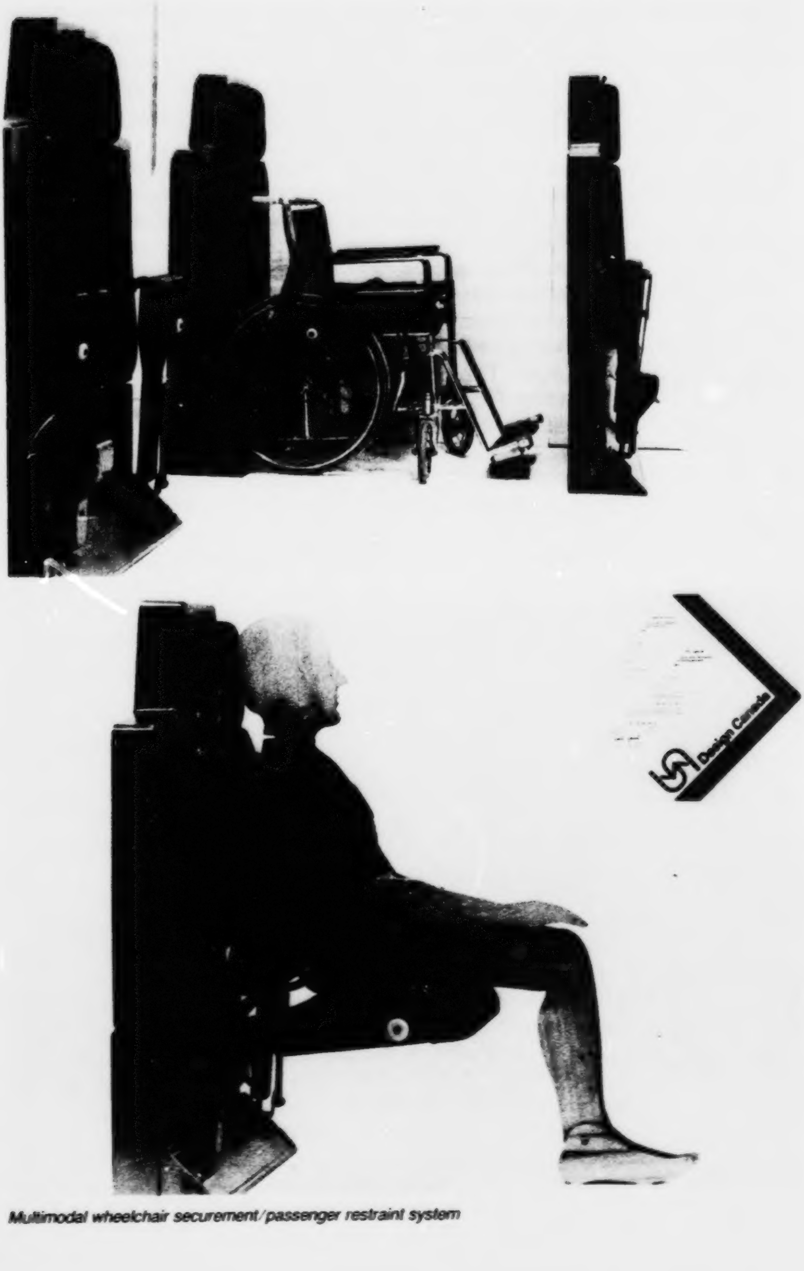
Protective Containers for Wheelchairs: the development of containers for the transport of wheelchairs in the cargo compartments of aircraft.

Wheelchair Access System for Intercity Buses: the assessment of various access systems to intercity buses for wheelchair users.

Communication Aids for Travellers with Sight, Speech or Hearing Impairments: aids for handicapped people at federally run transportation terminals.

Computer Model for Scheduling and Routing of Special Public Transit Services: a system that will enable efficient scheduling of minibuses for the transportation of handicapped persons.

TDC recently prepared two helpful publications for travellers with special needs. "Compendium of Transportation Equipment for Disabled Persons" (TP 3618) is an international listing of transportation aids. Included are wheelchair lifts and loaders, securement systems and non-conventional wheelchairs. "Transportation in Canada: A Guide for Travellers with Special Needs" (TP 380) describes travelling procedures and transportation facilities for travellers with permanent or temporary disabilities.


Design Canada

Multimodal wheelchair securement/passenger restraint system

Multimodal Wheelchair Securement/ Passenger Restraint System

Description

Previous work commissioned by TDC in this area resulted in the development of a securement system for wheelchairs in railway passenger cars. The current project builds on the experience of that work. The objective is to enhance the safe transportation of wheelchair travellers through the development of a securement and restraint system that would have application to several transportation modes. Although specific consideration is given to vans, the system should also be suitable for use in intercity buses and ferries.

The concept for a wheelchair securement and passenger restraint system for vans was developed by Les Designers Douglas Ball Inc. The system is modular in design and consists of a wheel stop and securement arm, a lower back structure, a head and back support, and an optional seat suitable for use by any traveller.

In the current project, the developers designed and manufactured four prototype units. One prototype was strength tested in a laboratory and two were evaluated in service in the Handicab vans of M&O Bus Lines Ltd. of Ottawa. The fourth prototype was installed in a van that was subjected to a barrier crash test at Transport Canada's Motor Vehicle Test Centre in Blainville, Quebec.

Progress to May 1982

The laboratory tests and the in-service evaluation demonstrated that the system can provide a greater degree of safety to the wheelchair traveller in vehicles. The users rated the prototype system as satisfactory overall, although some improvements regarding comfort were suggested (e.g. lowering the shoulder belt, raising the seat module). This unit withstood the barrier crash test with no damage to the unit itself or to the wheelchair. The system won the Design Canada 1982 Special Award for Innovation, Research and Development.

Contractor

Les Designers Douglas Ball Inc., Ste. Anne de Bellevue, Quebec

Reports

TP 3057E, Multimodal Wheelchair Securement/Passenger Restraint: Prototype Development, Les Designers Douglas Ball Inc., May 1981.

TP 2179, Wheelchair Restraint System, Design for Multimodal Transportation, Douglas Ball Inc., July 1979.

Schedule: March 1979 — December 1981
Funding: TDC — $55,000

Project Number: 4074
File Number: D-1450-103-12
Project Officer: R.S. Nishizaki

Barrier-Free Terminals and Transfer Facilities

Description

Modern passenger terminals, particularly airports, are increasing in size and complexity, yet many lack adequate facilities for travellers with disabilities. This lack stems partly from inadequate guidelines for terminal design and partly from characteristics inherent in a transit terminal.

TDC is supporting this project to make the national transportation system accessible to all Canadian travellers through the development of guidelines for barrier-free terminal design.

The specific objectives of this project are to compile and disseminate a compendium of guidelines on the design of terminals accessible to travellers with special needs and to design a modular transfer vehicle to transport persons with limited mobility within air, rail and ferry terminals.

Investigators defined the special needs travelling population, reviewed existing literature, and developed designs to make terminal facilities accessible to all travellers. They visited major terminals to assess design features and determine the potential application of new or advanced technologies to terminal facilities.

Progress to May 1982

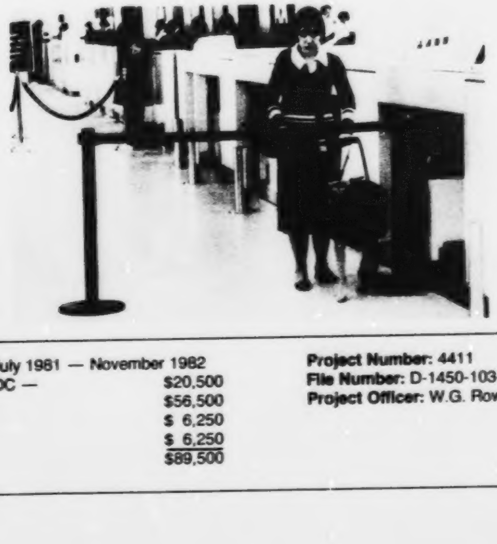
The investigators are completing compilation of the guidelines for the design of accessible terminals. They have also developed a conceptual design of the modular transfer vehicle. Driven by the traveller, an attendant or a terminal employee, this electric vehicle could transport passengers, including the wheelchair bound, and their luggage. With the completion of the data analysis phase of this project, a final concept for the vehicle will evolve.

Contractor

Les Designers Douglas Ball Inc., Ste Anne de Bellevue, Quebec

Reports

Draft, Travellers with Special Needs: Facility Design Compendium (Illustrated), Les Designers Douglas Ball Inc.
Draft, Travellers with Special Needs: Modular Transfer Platform, Design Concept, Les Designers Douglas Ball Inc.



Typical barrier confronting the sight-impaired traveller

Schedule: July 1981 — November 1982

Funding: TDC —	$20,500
DSS —	$56,500
CATA —	$ 6,250
DGSP —	$ 6,250
Total —	$89,500

Project Number: 4411
File Number: D-1450-103-41
Project Officer: W.G. Rowan

Quick-Release Hand Controls for Automobiles

Description

As more and more disabled Canadians travel for business and pleasure, the demand and need for rental automobiles with hand controls is also increasing. The Transport Canada Advisory Committee for the Transportation of the Handicapped recognizes this need.

The objective of this project is the development of a hand control system designed for quick installation and removal in rental automobiles. Fixed equipment — in other words, dedicated automobiles — appears economically impractical with the current low demand rate.

Investigators considered the needs of potential users and automobile rental companies. They also considered the regulations and licensing requirements across Canada as well as the technical aspects of such a development.

The project will culminate in the manufacture and functional testing of a prototype.

Progress to May 1982

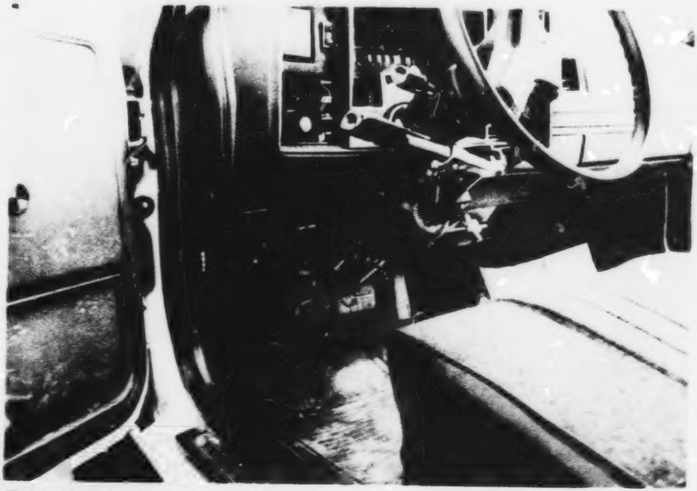
A prototype quick-release hand control was fabricated and tested. This unit is now being demonstrated to prospective users and automobile rental firms.

Contractor

Davis Engineering Ltd., Ottawa, Ontario

Report

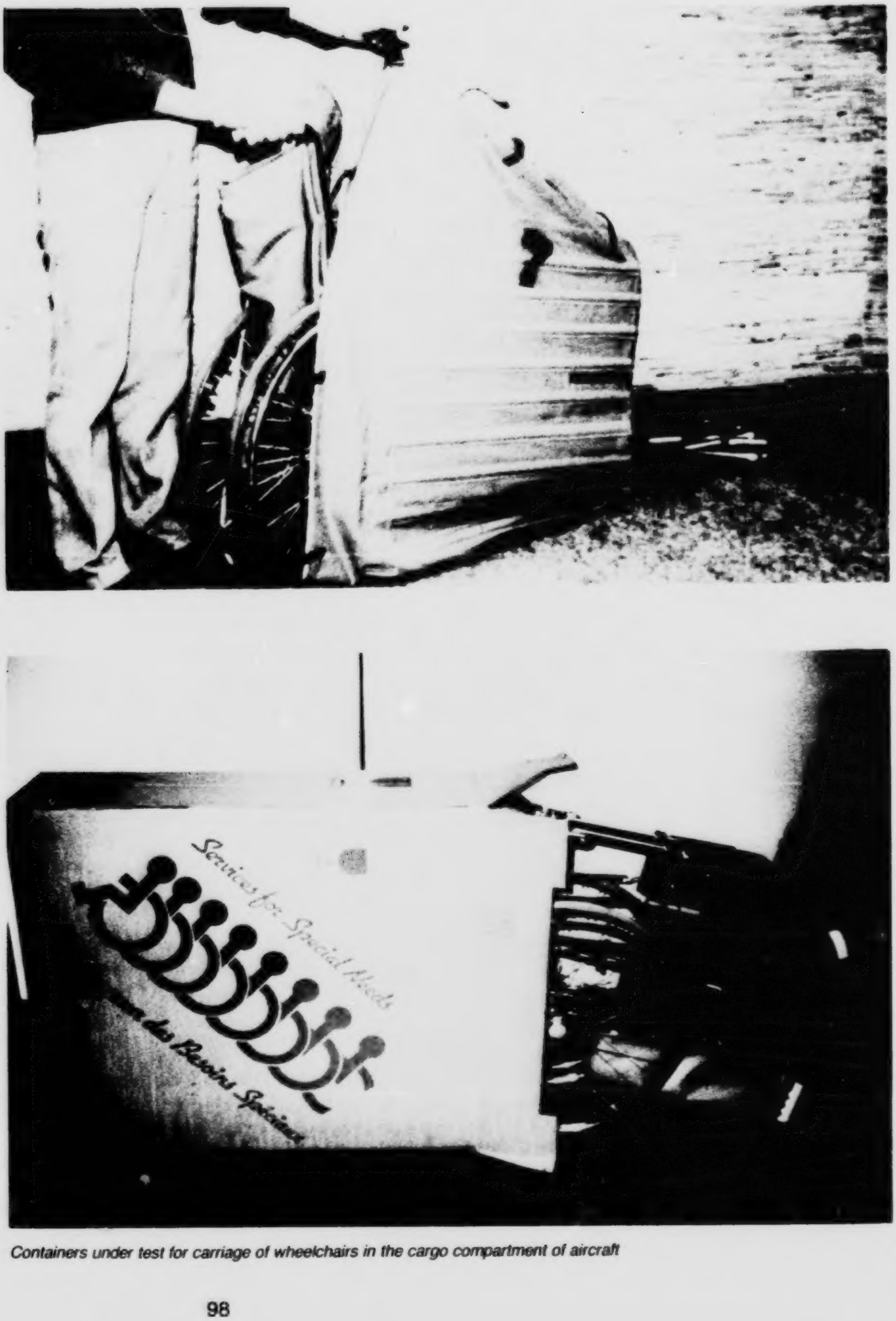
Draft, Quick-Release Hand Controls for Rental Automobiles: Prototype Design and Evaluation, Davis Engineering Ltd.



Quick-release hand control system

Schedule: July 1981 — August 1982
Funding: CSTA — $20,000

Project Number: 4421
File Number: D-1450-103-42
Project Officer: R.S. Nishizaki


Services for Special Needs
des Besoins Spéciaux

Containers under test for carriage of wheelchairs in the cargo compartment of aircraft

Protective Containers for Wheelchairs

Description

A recent Transport Canada report on the provision of services and facilities for disabled travellers includes a recommendation to develop means to assure the safe carriage of wheelchairs as baggage. The objective of this project is to develop a protective device to prevent or reduce the damage to wheelchairs carried as cargo in passenger aircraft and trains.

The project is being conducted in several phases. The first, a study of the present handling of wheelchairs as baggage by Canadian airlines, investigated various options available to airlines, including the provision of loaners or rental wheelchairs in airports. From this study the use of protective containers, reusable or disposable, was considered to have merit as a solution to the damage problem. Follow-on phases of the work led to the development of prototypes of canvas and cardboard box containers for folded wheelchairs. Preliminary tests indicate that the lightweight reusable canvas container offers the best protection while being the least awkward and time-consuming for airlines to handle.

The current phase of the work involves the testing by the airlines of 12 pre-production units of a refined design of the canvas container. The contractor is also designing a container for non-collapsible wheelchairs.

The results of this work should provide wheelchair travellers with greater freedom and confidence in their travels.

Progress to May 1982

Fabrication of pre-production units is nearing completion. Testing is scheduled to take place throughout summer 1982.

Contractors

Davis Engineering Ltd., Ottawa, Ontario
Hickling-Partners Inc., Ottawa, Ontario

Reports

Draft, Disposable Container for Transporting Wheelchairs: Prototype Development and Testing, Hickling-Partners Inc.

TP 3491E, Protective Container for Wheelchairs, Prototype Build, Davis Engineering Ltd., January 1982.

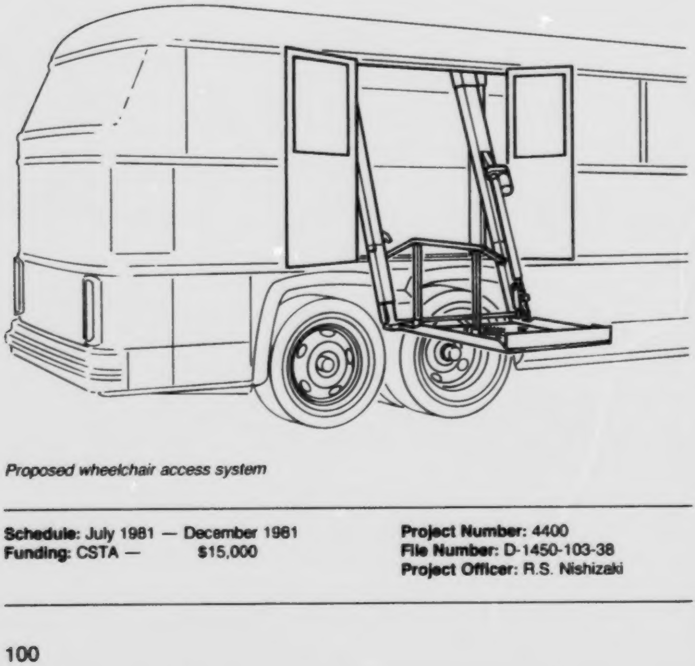
TP 3180, Protective Container for Wheelchairs, Feasibility Study, Davis Engineering Ltd., August 1981.

Schedule: June 1981 — August 1982
Funding: TDC — $46,000

Project Number: 4409, 4453, 4504, 4589
File Number: D-1450-103
Project Officer: W.G. Rowan

Wheelchair Access System for Intercity Buses

Description	The objective of this project was to evaluate promising equipment and configuration options for making intercity buses accessible to wheelchair users and to conduct a design study as a preliminary step to a demonstration program. Investigators studied questions concerning the selection, design and installation of a wheelchair access system suitable for intercity buses on regularly scheduled routes. These questions related to such factors as vertical travel distance of existing lifts, effect of dedicated doors on bus structural strength, reliability and maintainability of the system, and safety and cost considerations.
Progress to May 1982	This project is complete. Investigators studied the technical and safety requirements of a wheelchair access system, examined available lifts and securement mechanisms, and selected a promising system configuration. They also prepared preliminary installation layouts as well as a cost estimate and description of a demonstration program.
Contractor	TES Ltd., Ottawa, Ontario
Report	TP 3186, Wheelchair Access System for Intercity Buses, TES Ltd., September 1981.



Proposed wheelchair access system

Schedule: July 1981 — December 1981
Funding: CSTA — $15,000

Project Number: 4400
File Number: D-1450-103-38
Project Officer: R.S. Nishizaki

Communication Aids for Travellers with Sight, Speech or Hearing Impairments

Description

TDC's "Data Base Study for the Identification and Quantification of Transportation Handicapped Persons in Canada" (TP 2084) in 1979 established that more than 300,000 Canadians have sight, speech or hearing impairments that could hamper their progress through the public transportation network.

The objective of this project is to assess the communication and information needs of this segment of the travelling public on public transport vehicles and at terminals.

This work will include a comprehensive evaluation of the information transfer system of all public modes of transport under federal jurisdiction. The study will take into account trip planning, access, and system interface (terminals).

The contractor will identify and assess the communication needs of the target population, carrier policy on communications, and technology available on the market or in an advanced stage of development that could be used or adapted to supplement or replace present communication systems. The technology will include interactive systems, visual paging, visible/audible signalling, video boards, electronic guidance, teletext such as Telidon and visual ear, tactile information systems including braille, and electronic digitized speech and synthesized speech.

A panel of disabled persons will review, screen and refine all findings. The recommendations arising from this project will be used in Transport Canada's continuing effort to improve access to the national transportation system for Canadians with special needs.

Progress to May 1982

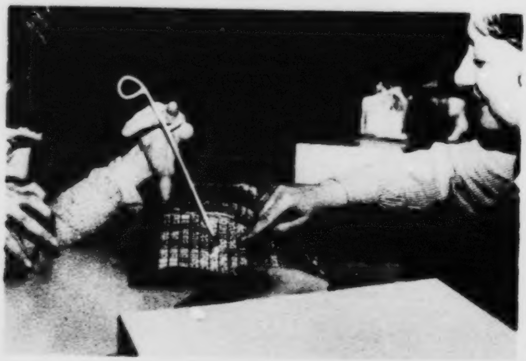
Communications policies of national carriers have been collated and a technical assessment of available technology has been completed. The review by the user panel is underway.

Contractor

IBI Group Inc., Toronto, Ontario

Report

None to date



Travellers with communication impairments frequently carry pictograph tables

---

Schedule: November 1981 — October 1982
Funding: TDC — $75,000

Project Number: 4466
File Number: D-1450-103
Project Number: W.G. Rowan

Computer Model for Scheduling and Routing of Special Public Transit Services

Description

More and more disabled Canadians are turning to special public transit services to get around their town or city. This escalating demand calls for increases in the efficiency and availability of these transit services, often resulting in their expansion in size and scope. Manual scheduling and routing of these larger transit systems is difficult, but no satisfactory computer model for this purpose exists at present. Consequently, the objective of this research project is to develop an advanced computer model that can be used to automatically schedule and route transit services for disabled persons.

The model must be able to interface with the wide variety of data bases already compiled by transit operators across the country. These data bases normally include such information as origins and destinations of passengers, time of pick-up and drop-off, travel distances between pick-up points, travel times at various periods of the day, and equipment available. The model would integrate this information with demands for new service requests or cancellations and provide automatic scheduling and routing.

Researchers will test the model in four Canadian cities of different size, and prepare a user's manual.

The results of this project will promote the efficient use of vehicles and drivers in the operation of transportation systems adapted to the needs of disabled travellers.

Progress to May 1982

This project has just started.

Contractor

Centre de recherche sur les transports, Université de Montréal, Montreal, Quebec

Report

None to date

Schedule: June 1982 — December 1983

Funding: TDC —	$49,768
Roads and Transportation Association of Canada —	$50,000

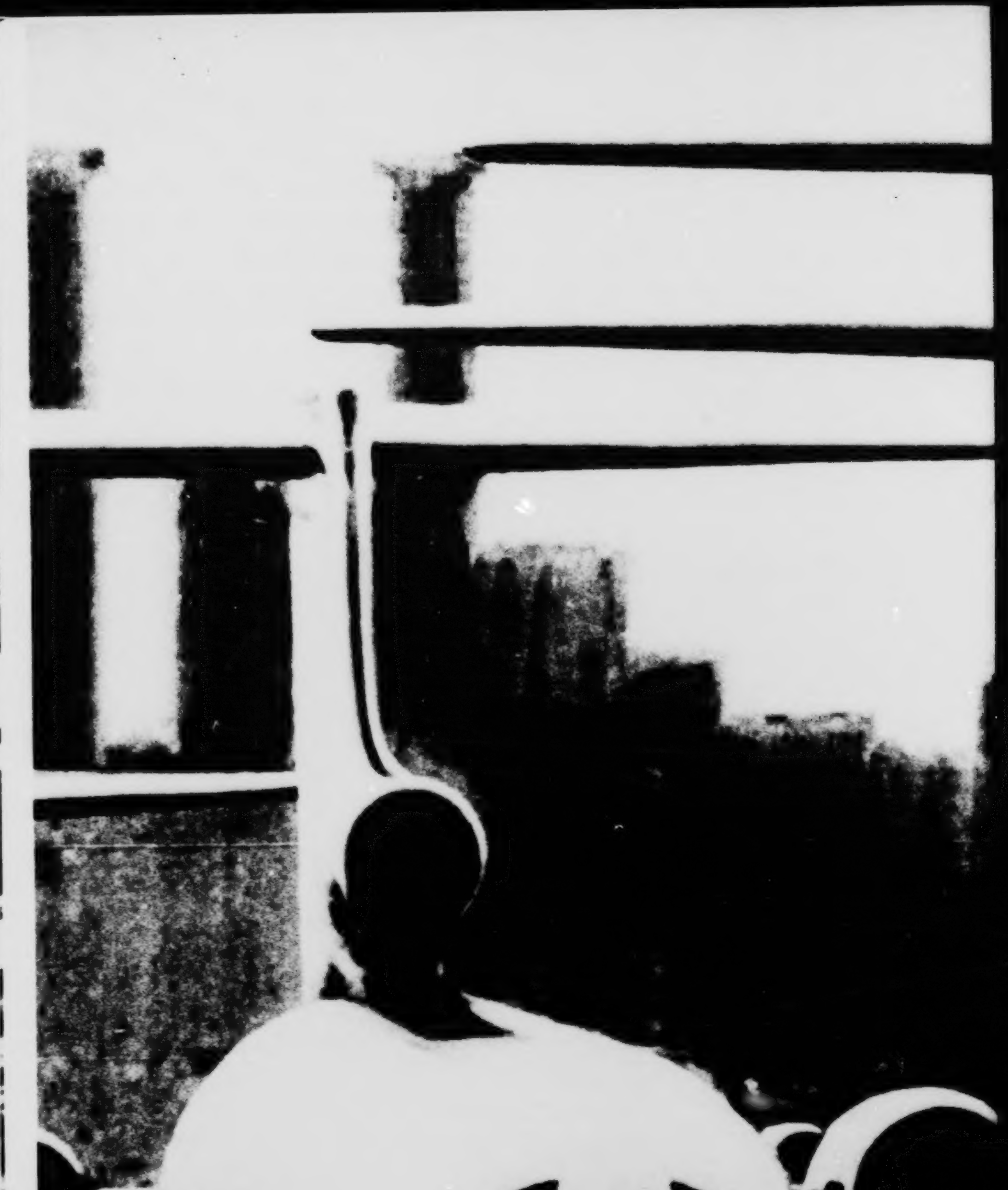
Project Number: 4712
File Number: D-1450-103-51
Project Officer: S. Corbeil

Air Technology

Energy Conservation **105**

Air Safety and Systems **111**

Communications and Control **121**



Energy Conservation

Early in 1977 Transport Canada began encouraging Canadian operators of large jet aircraft to adopt refined operating techniques in order to conserve energy. Transport Canada also recognized that technological changes could significantly improve aircraft fuel efficiency. These changes lie in the areas of aerodynamics, structures and propulsion systems.

A major research and development program to improve the energy efficiency of wide body aircraft is underway in the U.S., but no comparable activity is underway in the U.S. or elsewhere for smaller transport aircraft.

TDC, in recently completed projects, has identified research initiatives that could lead to the design and development of more energy-efficient aircraft and engines of a size and type suitable for Canadian manufacture, marketing and application. This research builds upon the indigenous Canadian experience of Pratt & Whitney Aircraft of Canada Ltd., the de Havilland Aircraft of Canada Ltd., and Canadair Ltd. to design and manufacture, respectively, small gas turbine engines, STOL and small transport aircraft. For each category the initiatives identified have formed the basis for major programs currently underway, namely:

Mixed Flow Turbine Study
Fuel Efficient STOL Aircraft
Small Transport Aircraft Fuel Efficiency

Two other projects relating to energy conservation are:

Augmentor Wing Cruise Performance Study: an investigation of the benefits of an augmentor wing under cruise conditions.

Gas Turbine Ceramics Technology: the development of a ceramic shroud for aircraft engines.

Mixed Flow Turbine Study

Description

In 1977, under TDC sponsorship, Pratt & Whitney Aircraft of Canada Ltd. began studies into the energy efficiency of turboprops and turbofans and the improvements that could be expected over a ten-year period.

After only three years of research into single-stage, axial flow gas generator turbines, Pratt & Whitney researchers identified discrete design refinements that improved energy efficiency by 1.7 per cent. The original 1977 forecast predicted improvements of 1.8 per cent in ten years.

This research also revealed that a mixed flow turbine has great promise to be more fuel efficient than either the radial flow or axial flow turbine, while combining the high efficiency of the former and the low weight of the latter.

In this project, researchers will design and test mixed flow turbines with an efficiency goal of 87 per cent.

Progress to May 1982

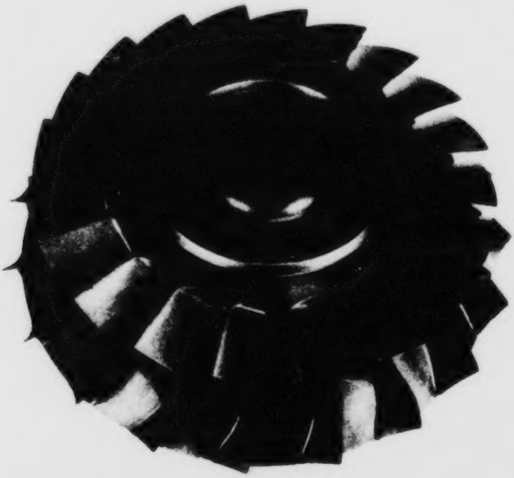
The analytical and design work necessary for the manufacture of test units has been completed. This work also included the study of innovative manufacturing techniques. The construction of test units is proceeding and the units will be available for testing early in 1983.

Contractor

Pratt & Whitney Aircraft of Canada Ltd., Longueuil, Quebec

Report

None to date



Mixed flow turbine under development by Pratt and Whitney

Schedule: July 1981 — December 1982

Funding: TDC —	$140,000
Energy R&D Panel —	$100,000
Pratt & Whitney Aircraft —	$240,000
Total —	$480,000

Project Number: 4300
File Number: D-1455-112-7
Project Officer: D. Hanchet

Fuel Efficient STOL Aircraft

Description

A parametric study carried out for TDC by de Havilland Aircraft of Canada in 1977 showed that significant improvements in the fuel efficiency of short take-off and landing (STOL) aircraft could be achieved through new technology. Using 1976 performance data as a baseline, researchers forecast 25 to 50 per cent increases in fuel efficiency achievable over a ten-year period. To confirm these results, TDC sponsored a three-stage program of experimental work, largely in aerodynamics.

This program, in conjunction with similar work by de Havilland for the National Research Council, is expected to lead to significant improvements in the productivity and fuel efficiency of Canadian-designed STOL aircraft.

Progress to May 1982

Researchers designed an inboard wing section using modern methods of airfoil design and analysis. Wind tunnel tests confirmed that the forecast improvements in fuel efficiency were achievable. Similarly, a propeller blade root section and mid-span and outboard wing sections were designed and tested; a small increase in propeller thrust and a significant reduction in propeller weight support the fuel efficiency improvement forecasts.

The design of a tip section of a propeller blade has been completed and tests are underway. With the results of these final tests, sufficient information will be available to design a complete propeller blade and wing.

Contractor

de Havilland Aircraft of Canada Ltd., Toronto, Ontario

Report

TP 2793, Energy Efficient STOL Transport Aircraft: Phase I, Findings and Research Recommendations, summary report, de Havilland Aircraft of Canada Ltd., November 1980.

Propeller air foils under test by de Havilland Aircraft at the NRC wind tunnel

Schedule: April 1980 — December 1982		**Project Number:** 4079
Funding: TDC —	$ 98,000	**File Number:** D-1455-112-6
Energy R&D Panel —	$100,000	**Project Officer:** D. Hanchet
de Havilland —	$ 66,000	
Total —	$264,000	

Small Transport Aircraft Fuel Efficiency

Description

In 1977 Canadair conducted, on behalf of TDC, a parametric study into the improvements in the fuel efficiency of small transport aircraft that could be realized through new technology. Using 1976 technology as a baseline, researchers predicted 20 to 40 per cent increases in fuel efficiency achievable over a ten-year period. To confirm the study results, TDC sponsored a three-phase program of detailed analytical and experimental work to be devoted largely to engine installation and wing configurations.

The first phase identified the effects of composite materials, advanced power plants and modern wing design techniques on overall aircraft fuel efficiency. In the second phase, the aerodynamic improvements were verified in wind tunnel tests.

In the final phase, the preliminary design of a fuel efficient transport aircraft will be undertaken in sufficient detail to help establish the configuration of a test model.

The test model configuration is expected to be a forerunner of a new aircraft, which may be a derivative of Canadair's *Challenger* or its successor.

Progress to May 1982

The wind tunnel test results have shown that the wing configurations selected can meet their share of the predicted fuel efficiency improvements. The analytical work for the final phase, including a detailed preliminary design of an aircraft, is continuing.

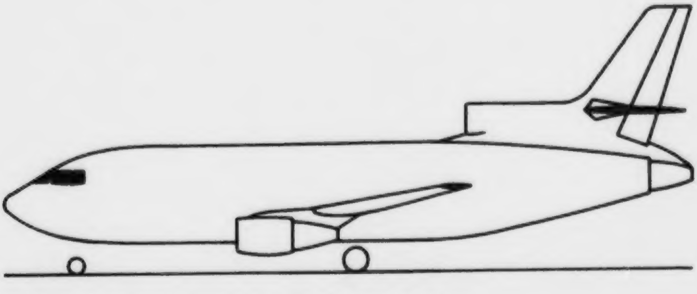
The study results have prompted the National Research Council to consider a major study of the structural aspects of a full-scale wing made of composite materials.

Contractor

Canadair Ltd., Montreal, Quebec

Report

TP 3021, Energy Efficient Aircraft Study, Phase II, summary report, Canadair Ltd., June 1981.



Energy efficient aircraft configuration: wing aspect ratio of 12 and wing quarter-chord sweep of 25°

Schedule: September 1981 — September 1982

Funding: TDC —	$ 50,000
Energy R&D Panel —	$100,000
Canadair Ltd. —	$150,000
Total —	$300,000

Project Number: 4302
File Number — D-1455-112-5
Project Officer: D. Hanchet

Augmentor Wing Cruise Performance Study

Description

For many years de Havilland Aircraft of Canada has been investigating augmentor wing (AW) technology — the induced flow of air over specially designed wing flaps — as a means of achieving very short take-offs and landings. In the course of these studies, de Havilland discovered that the AW configuration, when operating at cruise speeds, produces low drag.

The purpose of the present study is to explore the economic significance of this characteristic, especially its effect on fuel efficiency, by simulating the performance of an AW aircraft and a comparable conventional-wing aircraft.

This exploratory research may result in dramatic changes to the wing design of future aircraft.

Progress to May 1982

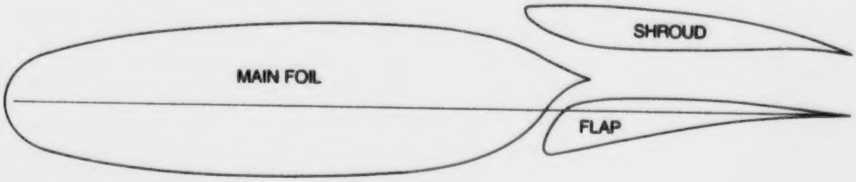
This project has just started.

Contractor

de Havilland Aircraft of Canada Ltd., Toronto, Ontario

Report

None to date



Section of a multi-foil wing with 18%-thickness chord

Schedule: March 1982 — August 1982
Funding: TDC — $45,000

Project Number: 4313
File Number: D-1455-137
Project Officer: D. Hanchet

Gas Turbine Ceramics Technology

Description

The objective of this project is to optimize the design of a gas generator turbine shroud lined with a ceramic material for aircraft engines.

Ceramics can reduce the weight and specific fuel consumption of aircraft engines, but high fabrication costs and excessive brittleness have in the past offset these advantages. Recent advances in ceramic technology have permitted its successful use in missiles and ground-based turbines.

Pratt & Whitney Aircraft of Canada has developed and tested ceramic shrouds; results show that these shrouds permit closer control over blade tip clearances, resulting in fuel savings of 1.25 per cent. This improvement is significant when compared to those achieved through aerodynamic changes.

This project is aimed at optimizing tip clearances on an existing Pratt & Whitney engine and, if successful, will lead to hot-engine tests and an in-service demonstration.

Progress to May 1982

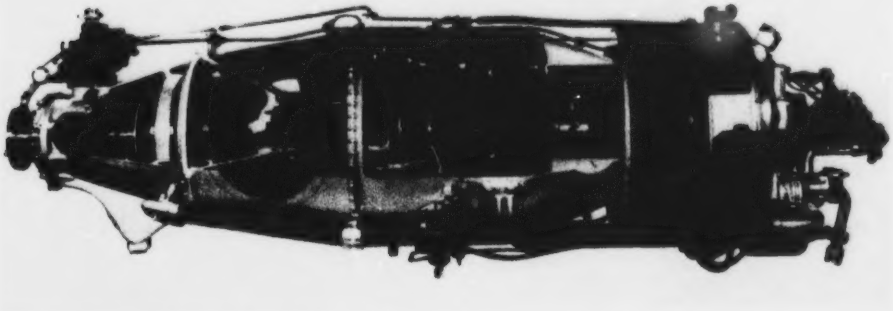
This project is in the planning phase.

Contractor

Pratt & Whitney Aircraft of Canada Ltd., Longueuil, Quebec

Report

None to date



PT6 turboprop on which ceramic liners will be tested

Schedule: November 1982 — July 1983
Funding: TDC — $60,000
Pratt & Whitney Aircraft of Canada — $20,000

Project Number: 4724
File Number: D-1455-112-1
Project Officer: D. Hanchet

Air Safety and Systems

Transport Canada is responsible for the regulation of aircraft standards and operational procedures within Canadian air space. The department reviews air regulations regularly to ensure that they can accommodate new technological developments, are compatible with public concerns and do not unduly compromise aviation activities or safety. To conduct such reviews, Transport Canada must have available not only all the pertinent information but also expert personnel familiar with the technical, environmental, social, economic and political aspects of these regulations.

TDC supports research and data collection activities necessary to define regulations as well as the requirements and means for compliance by aircraft operators. Current work includes:

Crashworthiness of Light Aircraft Structures: a study of the stress behaviour of aircraft structures of Canadian design.

Sonic Boom Research: a study to determine the effects of sonic booms on humans, animals and structures in anticipation of supersonic air corridors over Canada.

Light Bulb Filament Impact Dynamics: the collection of data on light bulb filaments for the use of aircraft accident investigators to infer the state of an electrical circuit at the moment of impact.

Toronto International Airport Intra-Airport Transportation Study: the development of an intra-airport transportation system for sprawling multi-terminal airports such as Toronto International Airport.

Airport Application of ICTS: Feasibility Study: an inquiry into the suitability of the Urban Transportation Development Corporation's ICTS vehicle for airports.

Canadian Floating Offshore Air Terminal: an investigation of innovative concepts for a floating offshore facility for STOL/VTOL aircraft serving oil exploration bases.

Transport Systems Safety Research: a review of current safety regulations.

Crashworthiness of Light Aircraft Structures

Description

In anticipation of the legislation of new U.S. Federal Aviation Regulations (FAR) requiring that aircraft be designed to withstand (within limits) ground impact, TDC initiated a study of the dynamic stress behaviour of aircraft structures of Canadian design.

This study yielded data on experimental impacts of an aluminium fuselage structure for various vertical impact velocities and loadings. A preliminary computer model based on a lumped spring-mass analogy predicted with reasonable accuracy the structural responses up to the set limits. Researchers then conducted fuselage model impact tests with progressively higher loadings so that nonlinear plastic deformation and permanent buckling occurred. They also determined the cross-coupling and damping terms required for a general computer model. Predicted behaviour was compared with experimental data and they corresponded for horizontal and oblique angle impact tests.

In the current project, researchers are modifying the computer model so that it will adequately describe the complex dynamic structural behaviour of an aircraft fuselage structure under various impact conditions and thus permit assessment of compliance with FAR.

Progress to May 1982

The computer model was modified to address large plastic deformation, buckling and local fracture of discrete elements of the fuselage structure; to predict corresponding behaviour of fuselage structures under oblique angle impact for large values of wing loading; and, to compare predicted and experimentally measured values of deflection and g loads (horizontal and vertical) at set structure and wing load pick-up points. The model's predictions closely correlated with the results of the drop tests of the fuselage structures with both horizontal and vertical velocity components. A final report is in preparation.

A user's manual for the computer model has been drafted and is under review by the Canadian Air Transportation Administration. Results are being tabulated and will be made available to manufacturers of light aircraft.

Contractor

University of Toronto, Institute for Aerospace Studies, Toronto, Ontario

Report

TP 2616, Crashworthiness of Light Aircraft Structures, University of Toronto, Institute for Aerospace Studies, March 1980.

Schedule: April 1978 — October 1982

Funding: TDC —	$ 70,000
National Research Council —	$ 15,000
UTIAS —	$ 30,000
de Havilland —	$ 24,000
Total —	$139,000

Project Number: 7661
File Number: D-1455-106-1
Project Officer: C.A. Versailles

Sonic Boom Research — Phase III

Description

Aircraft operating faster than the speed of sound (1000 km/h) produce a sharp shock wave or "sonic boom" that can startle humans and animals and vibrate structures. The operation of supersonic aircraft in domestic and international commercial service over Canadian air space will depend on whether supersonic corridors can be permitted in Canada. Consequently, air regulations must be written based on a sound knowledge of sonic boom effects in the Canadian context.

In previous work, researchers at the University of Toronto Institute for Aerospace Studies (UTIAS) investigated the aerodynamic effects of sonic booms on structures, the physiological effects on animals, and the psychological effects on humans.

In the current project, they are continuing analysis of crack propagation in wood and plaster rooms subjected to simulated sonic booms and investigation of pathological changes to the inner ear of animals due to sonic booms. They will also study the evolution of the N-wave in real atmospheric turbulence. The results of the N-wave studies should reveal why measured rise times are often found to be 100 or 1000 times greater than those predicted by analysis.

UTIAS researchers will use their special facilities for the investigations. These facilities include a loudspeaker-driven simulator that mimics various N-waves, pure tones, etc., and is well suited for studying psychoacoustic response and investigating physiological effects on small animals. Also available is a travelling-wave horn simulator, which can generate booms of varying intensity.

As in previous phases of this work, the National Research Council and the U.S. Air Force Office of Scientific Research are sharing the cost of hardware for the project.

Progress to May 1982

During the past year the animal research studies were completed. The main findings were inner ear bleeding and hearing threshold shifts in the upper range of perceived frequencies.

Studies of simulated supersonic pressures in a house model, represented by adjoining rooms connected by a window, indicated amplification of the pressure measured in single rooms. A thesis entitled "Human Response to Infrasound" based on findings of this project has been submitted to the university.

UTIAS is also applying its research findings to identifying the pressure signature of supersonic projectiles. This work is sponsored by the Department of National Defence.

Contractor

University of Toronto, Institute for Aerospace Studies, Toronto, Ontario

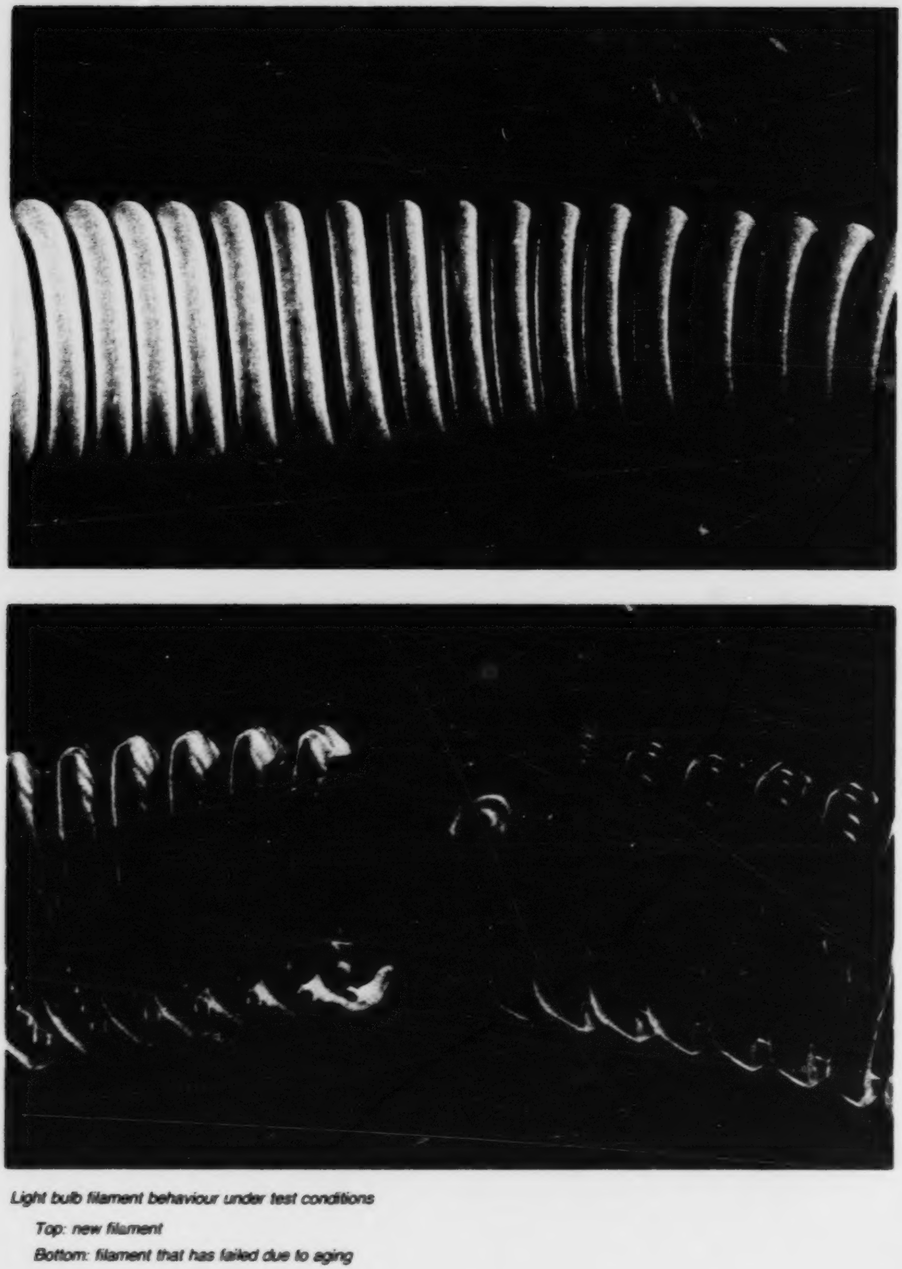
Report

TP 2599, Final Sonic Boom Report for the period 1977-1980, UTIAS, March 1980.

Schedule: April 1980 — March 1983

Funding: TDC —	$118,000
National Research Council —	$ 16,000
U.S. Air Force —	$ 16,000
Total —	$150,000

Project Number: 4120
File Number: D-1455-100-9
Project Officer: C.A. Versailles



Light bulb filament behaviour under test conditions

Top: new filament

Bottom: filament that has failed due to aging

Light Bulb Filament Impact Dynamics

Description

Light bulb filament analysis is a tool used by investigators of aircraft accidents to infer the state of an electrical circuit at the moment of impact. This information is especially critical for circuits associated with failure warning lights.

The definitive manual on the subject of light bulb impact analysis was published in 1966 by the Royal Canadian Air Force, but this manual requires updating in light of modern technology. The objective of this project is to provide a new manual to be used by accident investigators in the field and in the laboratory. The manual is expected to be included in the corresponding manual of the International Civil Aviation Organization.

TDC has undertaken a multi-year program in co-operation with the Aviation Safety Engineering (ASE) division of Transport Canada to study and test filament fracture theory. ASE equipment such as impact test machines, high speed cameras and electron microscopes is being used to a large extent, and all physical work is being conducted in ASE facilities.

The first year of the program was largely spent gathering information from light bulb manufacturers and other sources, designing specialized adapters and holders for existing ASE equipment, establishing test techniques, and preparing the test equipment.

Progress to May 1982

Researchers are completing the development of test techniques preparatory to the start of systematic tests. Finite element stress analysis of the filaments has been satisfactorily completed. It is expected that this analysis will permit more accurate predictions of impact dynamics and thus reduce the amount of experimental work necessary to complete the project. The tests will take place in late 1982.

Contractor

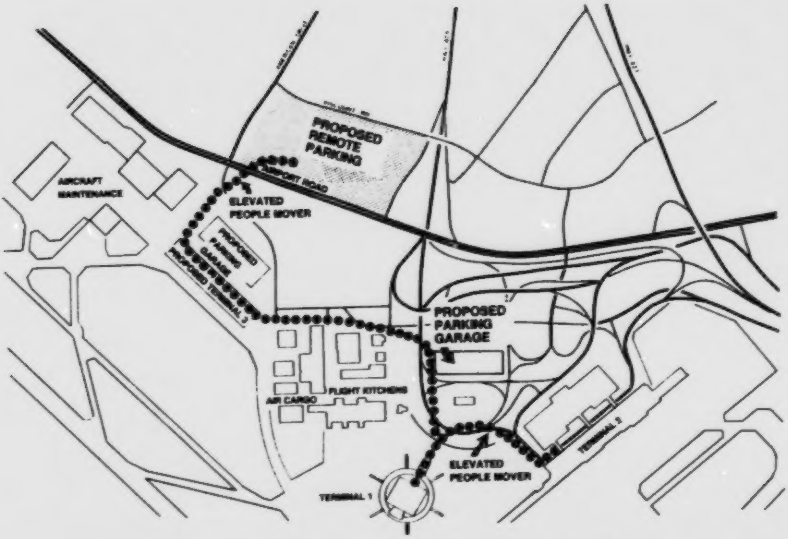
Transport Canada, Aviation Safety Engineering, Ottawa, Ontario

Report

None to date

Schedule: January 1980 — December 1983
Funding: TDC — $148,000

Project Number: 4028
File Number: D-1455-129
Project Officer: D. Hanchet


PROPOSED REMOTE PARKING
AIRPORT ROAD
AIRCRAFT MAINTENANCE
ELEVATED PEOPLE MOVER
PROPOSED PARKING GARAGE
PROPOSED TERMINAL 3
PROPOSED PARKING GARAGE
FLIGHT KITCHENS
AIR CARGO
TERMINAL 1
TERMINAL 2
ELEVATED PEOPLE MOVER

Proposed people mover alignment linking existing and possible future activity centres at TIA

Toronto International Airport

Toronto International Airport Intra-Airport Transportation Study

Description

The objective of this study is to evaluate the need for an intra-airport transportation system at Toronto International Airport (TIA) and to develop alternative plans to meet these needs to the year 2000 and beyond. The system, in the context of this study, includes vehicle parking, intra-airport circulation and airport access.

Projected growth in air traffic at TIA has led to the recommendation that a third terminal be constructed. This addition would permit the realization of the full capacity of the existing runway system.

The anticipated growth of air traffic will also necessitate an expansion of parking facilities and the provision of an efficient means of moving passengers and employees between parking facilities, terminal areas and other points within the airport. Also, the possibility exists that one or more of the Toronto area rail transit systems (LRT, ICTS, subway or GO) will be extended to the airport. Such an expansion would necessitate the installation of a collector/distributor system within the airport to move transit passengers between the transit stations and the airport.

In previous work on this project, investigators analyzed the requirements for an intra-airport transportation system and developed long range solutions to meet these requirements. Candidate intra-airport transportation systems were identified and evaluated. Four were selected for further study: a shuttle bus system and three guideway systems, the Urban Transportation Development Corporation's ICTS, Westinghouse, and Disney-Turner's WEDway.

Progress to May 1982

A detailed study of the four selected systems has been completed. An architectural impact study has also been completed. TDC is reviewing the results of this work.

Contractors

Urban Transportation Development Corporation, Kingston, Ontario
DeLeuw Cather Canada Ltd., Ottawa, Ontario
WED Transportation Systems Inc., Orlando, Florida
Westinghouse Electric Corporation, West Mifflin, Pennsylvania
NORR Airport Planning Associates Ltd., Toronto, Ontario

Reports

Draft, TIA Intra-Airport Transportation Study, final report, TDC.

Schedule: December 1981 — November 1982
Funding: TIA — $50,000

Project Number: 4417, 4418, 4419
File Number: D-1455-134-1
Project Officers: L. Suen, L.A. McCoomb

Airport Application of ICTS: Feasibility Study

Description

The objectives of this project were to define the operational requirements for a people mover for groundside transportation at Canadian airports, and to study the Urban Transportation Development Corporation's intermediate capacity transit system (ICTS) for this application.

Under development for the past six years, the intermediate capacity transit system is a steel wheel on rail system employing a linear induction motor for propulsion, steerable trucks to minimize noise and energy consumption, and elevated guideways to permit its use in developed areas. ICTS is aimed at the transit markets that are larger than those served by buses, but that do not justify the installation of subways. This market characteristically has a capacity range of 5,000 to 20,000 passengers per hour per peak direction. Its intermediate capacity makes this type of automated transit system ideal for application in airports requiring transportation service between terminals, between a terminal building and a remote parking location or between airside and groundside facilities.

In the study of the operational requirements of a people mover, the contractor addressed performance, reliability, environmental impact and passenger service features. In the ICTS application study, the contractor assessed the system's compatibility with national and international airport operations.

Progress to May 1982

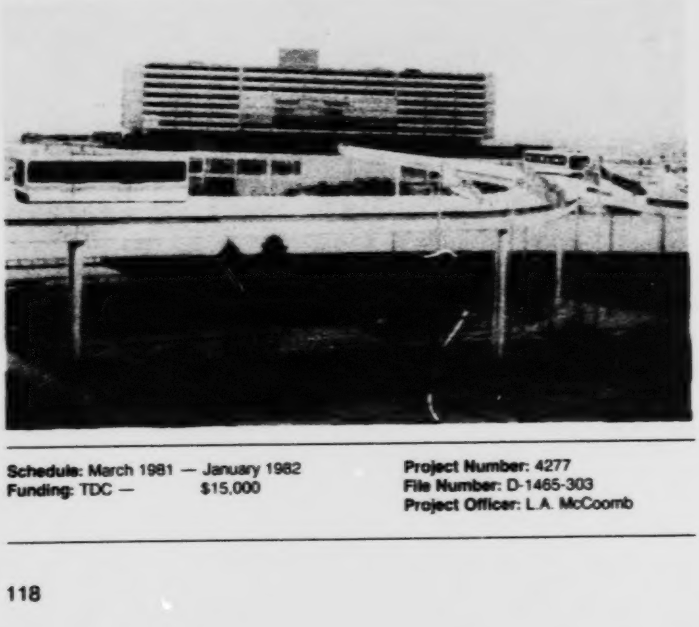
This project is complete. The studies concluded that ICTS meets all the requirements for an airport people mover and that its present design is fully compatible technically with any airport operation.

Contractor

Urban Transportation Development Corporation, Kingston, Ontario

Report

TP 3011, Feasibility Study of ICTS in Airport Applications, Urban Transportation Development Corporation, November 1981.



Conceptual airport layout of UTDC's intermediate capacity transit system

---

Schedule: March 1981 — January 1982
Funding: TDC — $15,000
Project Number: 4277
File Number: D-1465-303
Project Officer: L.A. McCoomb

Canadian Floating Offshore Air Terminal

Description

The objectives of this project are to investigate concepts of an offshore floating air terminal for use in Canadian offshore oil resource development, particularly in the Atlantic region; and to identify and evaluate technical innovations for floating airports in the context of Canadian requirements and technological capabilities.

The development of offshore oil resources is a national priority. In Canada, such exploration is undertaken in climates and environments that present major problems for the movement of persons and materials to offshore sites. A centralized, movable transportation facility serving as an offshore waystation and maintenance base to dispersed exploration rigs has been suggested as a means of providing access for larger aircraft, possibly STOL and/or VTOL aircraft.

TDC has defined a multi-phase project that will have the industry and government involvement necessary for an undertaking of this magnitude. The first phase of the project will include:

- a review of the operational requirements for transportation and supply in the offshore oil exploration environment on the Canadian east coast;
- a study of the operating environments (i.e., wind force, wave height and direction); and,
- an assessment of the benefits of using centralized facilities both on and offshore.

Progress to May 1982

Phase one of this project is in the planning stage.

Contractor

IBI Group Inc., Toronto, Ontario

Report

None to date

Concept of floating offshore air terminal

Schedule: May 1982 — March 1983
Funding: TDC — $ 60,000
DSS — $140,000

Project Number: 4610
File Number: D-1455-144
Project Officer: M. Tapiero

Transport Systems Safety Research

Description

The objective of this project is to develop a systems safety methodology, applicable to all transportation modes, which will help to establish research and development needs and provide a measure of the safety improvements achievable through technology R&D.

This work is an outgrowth of a TDC study on the costs of aviation accidents which concluded that little substantive research has been undertaken on systems safety methodology. The present project will provide Transport Canada with a structured approach to establish a comprehensive safety research and development program of activity extending to all modes of transportation.

Researchers will:

- review transportation safety management for all modes, identifying current safety programs, philosophies, measurement criteria and methods used to determine safety R&D activities;
- classify accidents and hazardous events, leading to a classification of required technology R&D activities; and,
- identify and analyze the impact of R&D on safety.

The project will be restricted to the study of the safety of vehicles, drivers, passengers or cargo, and will address operations, maintenance and training.

Progress to May 1982

This project has just started.

Contractor

Peat, Marwick and Partners Ltd., Montreal, Quebec

Report

None to date

Schedule: May 1982 — March 1983
Funding: TDC — $100,000

Project Number: 4557
File Number: D-1450-126
Project Officer: M. Tapiero

Communications and Control

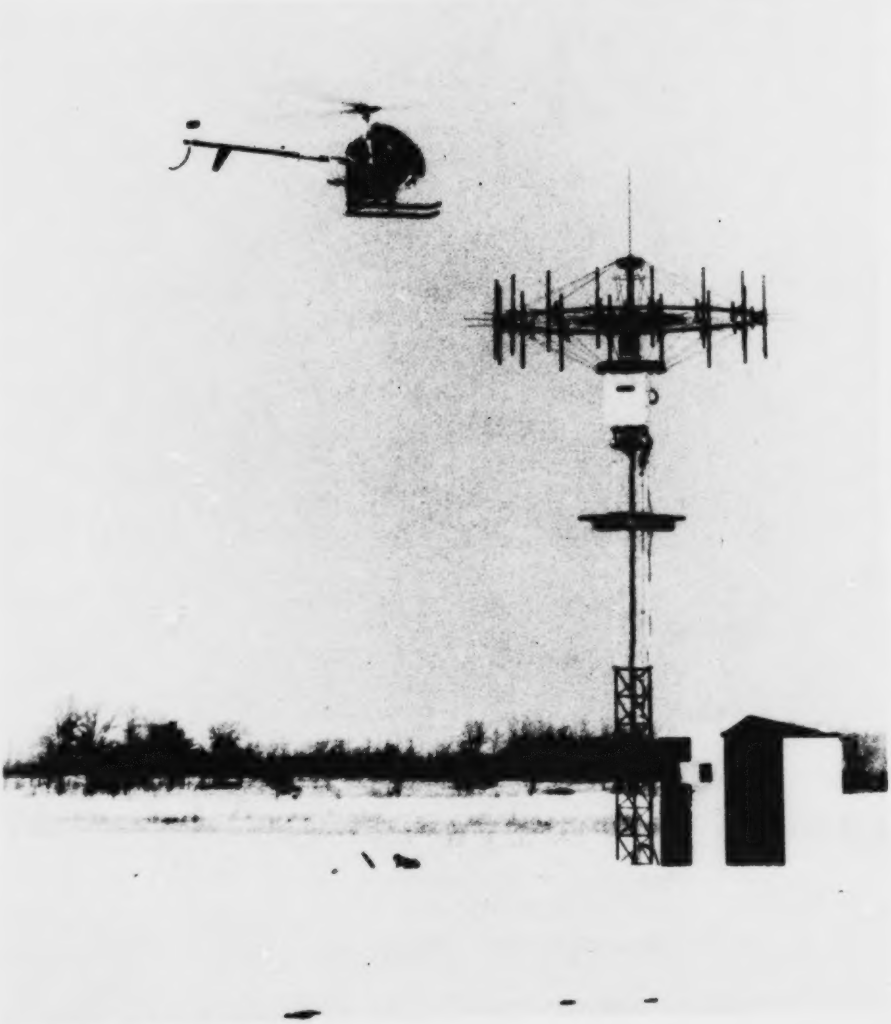
Projects in this section are concerned with new technology applicable to the operational aspects of air transportation. They relate to support systems, such as navigational aids, and to methods intended to increase operational efficiency.

Current work includes:

Doppler Radio Direction Finder — Operational Evaluation: the development of an improved VHF radio direction finder using modern, less costly components.

Aircraft On-Board Weight Sensor: the development of an on-board weight sensor for loading transport aircraft.

Unattended Navigation and Communications Facility (UNAVCOM): a project to demonstrate the feasibility of using a wind turbine to power navigation aids.



Doppler RDF installation at Kingston, Ontario

Doppler Radio Direction Finder — Operational Evaluation

Description

The purpose of this project is to improve the safety of air traffic operations by developing a more precise and reliable system for determining the azimuth of VHF radio communications. The equipment would be used at those airports not equipped with radar and at others, to facilitate the identification of aircraft and as a back-up to the radar in emergencies.

The doppler radio direction finder (RDF) has long been recognized as a practical navigational aid for air and marine traffic. Transport Canada's air and marine administrations make extensive use of radio direction finding in traffic control and search and rescue operations.

In this project, researchers will use advanced component technology and modern signal processing techniques to develop more accurate and reliable and less expensive equipment than the units now in service with Transport Canada. They will design, build and test a prototype RDF for fixed, land-based installation to operate in the civilian air traffic control band of 117.5 to 137.5 MHz. The equipment is to be of modular design so that it may be used with minimal modification in marine operations.

The result of this work should be the development of a state of the art, cost-effective Canadian radio direction finder.

Progress to May 1982

Researchers have completed system design and packaging. The experimental prototype was field-tested during September 1981 in Granby, Quebec. The unit is now undergoing operational evaluation at the Norman Rodgers Airport in Kingston, Ontario.

Contractor

Bayly Engineering Ltd., Ajax, Ontario

Report

None to date

Schedule: February 1980 — March 1983		**Project Number:** 4084, 4111
Funding: TDC —	$ 25,800	**File Number:** D-1455-133-1
Bayly Eng. Ltd. —	$ 91,000	**Project Officer:** N.E. Rudback
plus any additional costs		
DSS —	$250,000	
Total —	$366,800	

Aircraft on-board weight sensor
Top: light beam from fringe generator
Bottom: transducer

Aircraft On-Board Weight Sensor

Description

The need for a reliable on-board weight and balance system for transport aircraft stems from the twofold desire to ensure safety and to permit a more accurate determination of gross weight and centre of gravity before take-off. The present method of calculating weight and balance requires strict control of all weight changes between periodic weighings, and time-consuming manual calculation of fuel and payload changes.

Dynamic Sciences Limited developed an innovative weight sensing system that uses fiber optic technology to measure landing gear axle strains. A reliable sensing system is critical to the development of an on-board weight and balance system, for which a worldwide market has been identified.

In the current project the contractor will develop a specification for an on-board weight sensing system and design the necessary optical electronic and mechanical components to build and test a prototype system.

Progress to May 1982

The general requirements for the sensor have been documented and detailed specifications for the weight sensing transducer defined. The first design review of the prototype system is scheduled for August 1982.

Contractor

DSL Dynamic Sciences Limited, Montreal, Quebec

Reports

TP 2544, Fiber Optic Weight Sensor, Dynamic Sciences Ltd., December 1979.
TP 2543, Fiber Optic Weight Sensor, summary report, Dynamic Sciences Ltd., December 1979.

Test set-up for aircraft on-board weight sensor

Schedule: September 1981 — September 1983

Funding: TDC —	$192,000
DSS —	$200,000
National Research Council —	$ 90,000
Total —	$482,000

Project Number: 4204
File Number: D-1455-117-2
Project Officer: D. Hanchet

Unattended Navigation and Communications Facility (UNAVCOM)

Description

The overall purpose of this project is to demonstrate the technical and economic feasibility of an unattended navigation and communications facility (UNAVCOM), powered by a wind turbine, to provide air navigation and air-ground communication services.

A study carried out in 1975/76 for Transport Canada into aeronautical communications and navigation in the Arctic and other remote areas of Canada proposed a family of navigation and communication facilities capable of remote, unattended operation, requiring little maintenance and consuming a minimum of energy. The system also features low capital and operating costs.

In addition to permitting the cost-effective extension of navigation and communication services to remote regions, UNAVCOM has the potential to greatly reduce the cost of such services in the more populated areas of Canada. At present, navigation and communications stations are manned 24 hours a day, seven days a week. The development of a reliable electronic system could permit a significant reduction in the operating and maintenance costs of these stations.

Progress to May 1982

This project is complete. A prototype UNAVCOM system installed at Ottawa's Carp airport became operational in January 1981 and was monitored until August 1981. The radio equipment functioned in accordance with specifications. The VHF direction finder, however, was found to give reliable bearings only up to 30 nautical miles. VHF air-ground communication from the UNAVCOM facility to a manned terminal via the ANIK satellite was demonstrated successfully. The facility operated at a power level of 440 W continuously. Considerable difficulty in starting and operating with the vertical axis wind turbine (VAWT) was experienced. The frequent starting requirements in gusty wind conditions made the VAWT unsuitable as an unattended power source for this application.

The study concluded that a UNAVCOM facility is practical in a remote location with an adequate power supply.

Contractor

Satel Consultants Ltd., Ottawa, Ontario

Report

Unattended Navigation and Communications Station Powered by a Vertical Axis Wind Turbine and Propane Thermal Electric Generators, report no. C-81-86, Canadian Air Transportation Administration, May 1982.

Schedule: December 1978 — December 1981
Funding: TDC — $215,000

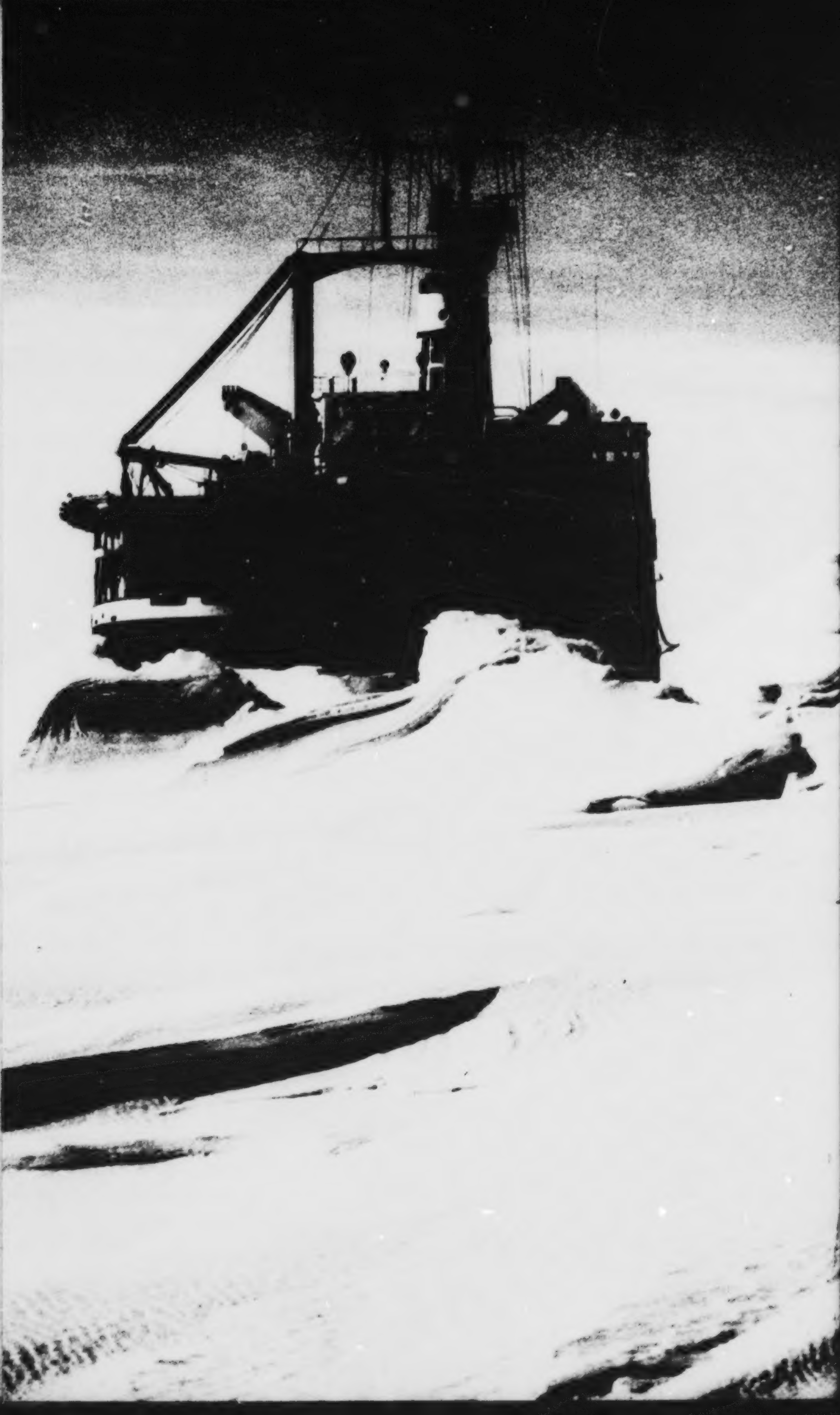
Project Number: 8869
File Number: D-1465-126
Project Officer: C.A. Versailles

Marine Technology

Arctic Vessel Research **129**

Icebreaking and Ice-Related Research **143**

Marine Transportation Systems **151**



Arctic Vessel Research

Year-round marine operations in Arctic waters would greatly expedite the development of Canada's northern resources. To achieve this, the federal government has significantly increased its support of Arctic marine transportation research and development.

Ships destined for Arctic supply and mineral exploitation will need to incorporate engineering and design features that permit icebreaking capability. These features apply not only to the hull but also to the propulsion package, control systems and ancillary equipment. The ramifications of increased marine activities in the Arctic will be more stringent designs of icebreaking vessels and the development of icebreaking cargo ships. The **M.V. *Arctic* Scientific Evaluation Program** is a major undertaking to evaluate this ice-strengthened cargo ship.

As larger ships venture further into ice-infested waters, propellers and shafts will have to withstand conditions heretofore unexperienced. Extensive research relating to regulations governing the design of these components and to the development of innovative methods for protecting them in ice is in progress. These projects are:

Propeller/Ice Interaction Model Tests
Finite Element Modelling of Propeller/Ice Interaction
Protection of Propellers in Ice
Semi-Empirical Ice Resistance Model
Arctic Ships' Heat Flow Model
Ice-Induced Hull Vibration

Other projects relate directly to information gathered from ship instrumentation and from operators and owners so as to gain a better understanding of manoeuvring in ice. These include:

Steering System Ice Loads, USCGC *Polar Star* 1982 Arctic Voyage
Ship Manoeuvring Simulation Development
Ballast Systems for Ice Navigation

M.V. *Arctic* Scientific Evaluation Program

Description

The *Arctic* is a Canadian built, ice-strengthened bulk cargo vessel. She is designed to meet Arctic ice class II specifications, which indicates a moderate icebreaking capability in accordance with the Arctic Shipping Pollution Prevention Regulations. This project constitutes instrumenting the ship for data collection and evaluation of environmental forces experienced during commercial operations in the Arctic. Results of this work will contribute to the development of Arctic shipping regulations.

Progress to May 1982

Reports describing the instrumentation system on the *Arctic* from July 1977 to July 1980 are available. The system continues to record hull strains due to ice impact, frequency of impact, ship machinery parameters (shaft r.p.m., fuel rack setting, torque, etc.) and ship speed, direction and motion. This information is presented in report form at the end of each operating season. Four series of trials have taken place to date: Saguenay River in January 1980, North Baffin Island area in October/November 1980, Lake Melville in February/March 1981, and Lancaster Sound area in November 1981.

A master data package that assembles in chronological order and standardized form the data bases gathered during each trial series is being compiled. Each data base is partitioned into three sections: description of system, voyage monitoring data, and dedicated trial data.

A plan has been developed for analyzing and evaluating ice transiting performance, manoeuvring, ship propulsion and structural loads. Work has also begun on the development and testing of the Navigation Warning System, which measures structural strains caused by ice impacts on the hull and provides warning displays and records for the benefit of the ship's crew.

Contractors

Arctec Canada Ltd., Kanata, Ontario
Fenco Consultants Ltd., Calgary, Alberta
German & Milne Inc., Montreal, Quebec
North Water Navigation Ltd., Montreal, Quebec

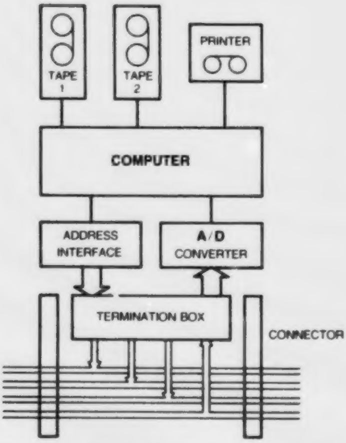
Reports

TP 3634, M.V. *Arctic* 1981 Late Season Data Collection and Instrumentation, Arctec Canada Ltd., March 1982.
TP 3633, M.V. *Arctic* 1981 Season Maintenance of the Data Gathering Instrumentation System, German & Milne Inc., January 1982.
TP 3097, M.V. *Arctic* Instrumentation and Data Collection System for Ship Operations in Ice, System Operating and User's Manual, 3 volumes, Fenco Consultants Ltd., May 1981.
TP 2956, M.V. *Arctic* Operational Evaluation, Maricon Ltd., January 1981.
TP 2681, M.V. *Arctic* Hull Vibration Study, Lloyd's Register of Shipping Ltd., February 1981.
TP 2690, Operational Maintenance Report for M.V. *Arctic* Data Acquisition System, 1979 Season, Phase VI, Refurbishing, German & Milne Inc., July 1980.
TP 2641, M.V. *Arctic* Scientific Evaluation Project, Data Collection Activity (1979-1980 season), summary report, German & Milne Inc., July 1980.
TP 2617, Operational Maintenance Report for M.V. *Arctic* Data Acquisition System, 1979 Season, Phases I-V, German & Milne Inc., March 1980.

TP 2218, M.V. *Arctic* Instrumentation and Data Gathering System for Ship Operations in Ice, System Operating and User's Manual, summary report, German & Milne Inc., July 1979.

TP 2217, M.V. *Arctic* Instrumentation and Data Collection System for Ship Operations in Ice, System Operating and User's Manual, 2 volumes, German & Milne Inc., July 1979.

Data acquisition station aboard the M.V. Arctic


TAPE 1
TAPE 2
PRINTER
COMPUTER
ADDRESS INTERFACE
A/D CONVERTER
TERMINATION BOX
CONNECTOR

Block diagram of central unit instrumentation system

M.V. Arctic

Schedule: February 1976 — December 1983

Funding: TDC —	$2,500,000
CMTA-AM —	$ 200,000
Energy R&D Panel —	$ 300,000
Total —	$3,000,000

Project Number: 4423, 4424, 4432, 4565, 4560, 4569
File Number: D-1460-166-4
Project Officer: M. Brenckmann

Propeller/Ice Interaction Model Tests

Description

To assist the Canadian Coast Guard (CCG) in its task of modifying regulations on the design of propellers and propeller shafts for ice class vessels, TDC recently sponsored the compilation of a digest of the rules of the world's classification societies (eleven in all) governing ice class propellers and propeller shafting. A review of this digest in the light of several recent propeller blade casualties indicated a need to improve existing rules and design formulas. TDC is therefore sponsoring this project, the objectives of which are:

- to establish the form and degree of correlation between full scale propeller/ice interaction and a physical model simulation of the interaction using synthetic ice;
- to apply the modelling process to generate a body of data on various propeller/ice interactions; and,
- to interpret the acquired data in terms pertinent to the regulation of the design of iceworthy propellers, as far as is feasible within the limited scope of this project.

This project is expected to provide industry and the CCG with fundamental information on the nature of propeller/ice interaction.

Progress to May 1982

Investigators have reviewed and analyzed data gathered by ice class ships to deduce loadings on propellers as a result of contact with ice. Tests with a scale model of a propeller have been run in synthetic ice, with instrumentation, to determine resulting stresses and forces.

Results of the full scale and model tests have been compared to deduce correlation functions and constants and assess the reliability of the model tests. Before proceeding with the generation of the reference body of data, TDC will review these results jointly with the contractor.

Contractor

Arctec Canada Ltd., Kanata, Ontario

Report

Draft, Experimental Determination of Factors Affecting Loads Imposed on Propellers in Ice, Arctec Canada Ltd.

Schedule: March 1981 — December 1982
Funding: TDC — $25,000
DSS — $75,000

Project Number: 4240
File Number: D-1460-156
Project Officer: I. Bayly

Finite Element Modelling of Propeller/Ice Interaction

Description

The objectives of this project are to reliably and accurately determine the distribution and level of stress in propeller blades in ice, including the effect of variations in blade dimensions and load distribution; and, to similarly assess the stresses and fracture patterns in the ice. The results of this work will be used to update the Arctic Shipping Pollution Prevention Regulations.

A typical modern icebreaker propeller will be modelled with a nominal loading of uniformly distributed pressure over the blade penetrating a block of ice. The stress distribution pattern and critical points where failure is likely to originate will be determined.

Similar finite element modelling will be carried out to assess sensitivity to a number of likely parametric variations, including:

- chord and thickness of the critical blade section, and
- primary performance dimensions, e.g. size, pitch, and area ratios; and secondary features, e.g. skew, rake, hub diameter, blade profile and section shape, pitch distribution.

Stresses in the ice block due to penetration of the propeller blade will also be assessed by finite element modelling. Likely fracture patterns will be determined, taking into consideration the material properties of ice in both isotropic and non-isotropic forms and under a range of temperatures and salinity conditions. Likely configurations of blade/ice interaction load distribution and intensity will be assessed, and compared with conventional assumptions.

A picture of the ice milling process will be defined and simplified formulas for predicting propeller/ice interaction forces will be developed. Other matters suitable for treatment by finite element modelling, such as stiffness and added mass, will also be assessed.

Progress to May 1982

Work on the first phase of this project is almost complete. Distribution and level of stress has been analyzed for several simple loading cases. Preliminary work has also been done on more realistic ice load distributions.

Contractor

Martec Ltd., Halifax, Nova Scotia

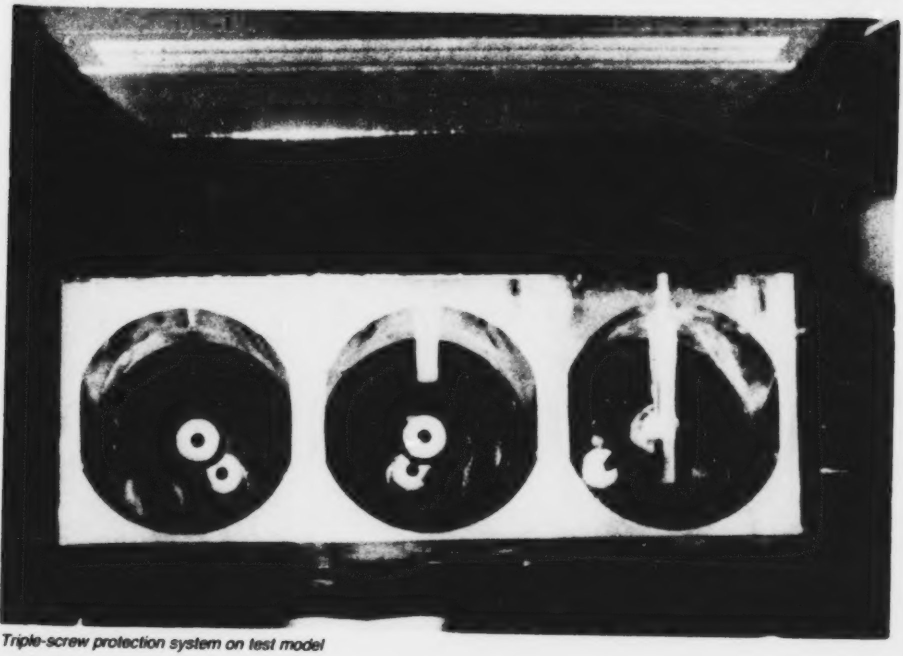
Report

Draft, Propeller/Ice Interaction Finite Element Stress Analysis, Martec Ltd.

Schedule: December 1981 — November 1982
Funding: TDC — $35,000
Energy R&D Panel — $30,000

Project Number: 4506
File Number: D-1460-156-3
Project Officer: I. Bayly

Side view



Triple-screw protection system on test model

Protection of Propellers in Ice

Description

The objective of this project is to develop a method of protecting the propellers of large icebreakers and icebreaking cargo vessels from damage caused by contact with heavy ice.

The risks of damage, pollution and financial losses as a result of propulsion system failure during northern operations increase dramatically as ships become larger and traffic in northern waters expands. A propeller protection system eliminating propeller/ice contact would not only minimize the risk of damage by ice, but would also permit the use of substantially lighter and more efficient propellers and other propulsion system components.

Screening systems for propellers are prone to rapid clogging with broken ice and excessive losses in propulsive efficiency. In this project, researchers are developing a system to minimize these drawbacks by investigating inflow velocities and ice shedding characteristics, as well as designs of propellers that would function efficiently in the flow conditions induced by the screening system.

The project consists of two phases. In the first phase, researchers conceptualized the design of propeller and shaft arrangements incorporating protection. The study included single, twin and triple screw applications. The second phase will consist of model testing to evaluate the protection effectiveness of the proposed arrangement and the propulsive efficiency.

Progress to May 1982

A triple screw protection system has been fitted to a model of a 150,000 shaft horsepower *Polar VII* hull. In recently completed resistance tests, the towed model showed unacceptable drag when compared to the conventional, unprotected *Polar VII* hull. This was initially attributed to the propeller protection equipment, but subsequent tests showed that the hull form at the aftersection was largely to blame.

Although the protection equipment was expected to cause some drag, calculations had shown that the tunnel/nozzle arrangement would produce a higher propulsive efficiency than the conventional configuration, and so help to negate effects of this additional drag. Recently completed tests with a self-propelled model are most encouraging in that, at 16 knots, the propulsive efficiency is 45 per cent higher than that of the conventional *Polar VII* hull.

Work remains to be done on the hull form, while the protection equipment requires streamlining. Data from open water tests of a model of the conventional hull with unprotected propellers are available for comparison with the results of the tests of the modified hull.

Contractor

Davis Engineering Ltd., Ottawa, Ontario

Report

TP 2704, Protection of Propellers in Ice, Volume 1: Assessment of Protection Schemes, Davis Engineering Ltd., August 1980.

Schedule: March 1980 — November 1982
Funding: Energy R&D Panel — $209,000

Project Number: 8951
File Number: D-1460-137
Project Officer: R.H. Dillon

Semi-Empirical Ice Resistance Model

Description

The objective of this project is to develop a new, more reliable method for predicting the resistance of a ship in ice. To achieve this the contractor will study full scale, model, and analytic data to develop relationships between shape, size, and other relevant hull parameters, ice properties, and resistance to motion of a vessel in ice.

Data related to ice resistance will be assembled and reduced to common terms. Hull geometry definition methods and analytic ice resistance prediction models will be reviewed, and effective methods for definition and analysis will be selected, or derived, to represent the current state of the art. Analysis of the data will enable development of new models and prediction methods.

An improved method to predict ice resistance of ships will greatly assist in the development of regulations for ships operating in the Arctic.

Progress to May 1982

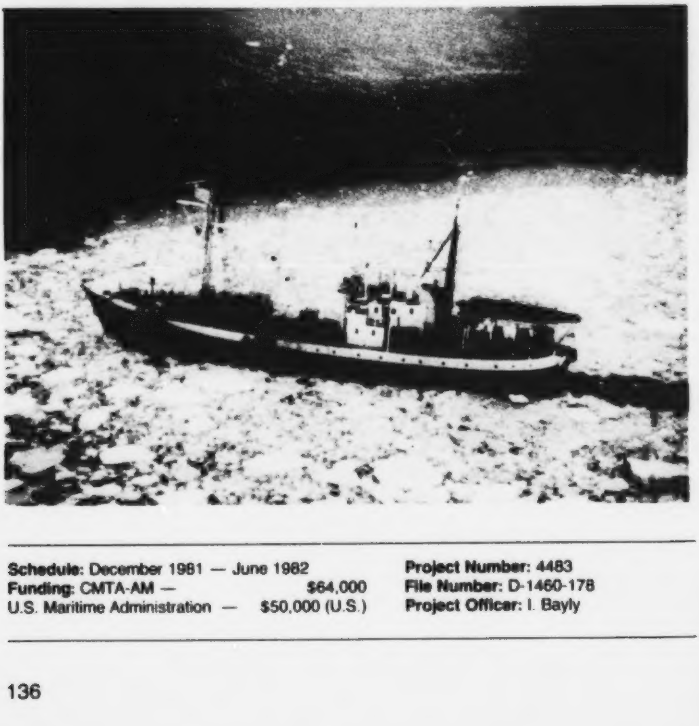
The data collection and storage and refinement of the analytic model have been completed. The final report is under review.

Contractor

Arctec Canada Ltd., Kanata, Ontario
Arctec Inc., Columbia, Maryland

Report

Draft, Development of a Semi-Empirical Model for Predicting Resistance and Determining Thrust Requirements for Ships in Level Ice, Arctec Canada Ltd.



Schedule: December 1981 — June 1982
Funding: CMTA-AM — $64,000
U.S. Maritime Administration — $50,000 (U.S.)

Project Number: 4483
File Number: D-1460-178
Project Officer: I. Bayly

Arctic Ships' Heat Flow Model

Description

Many ship steels become unacceptably brittle at temperatures below a critical transition temperature, which varies with the grade of steel. It is important, therefore, to know the temperatures of structurally significant ship components when exposed to the environmental conditions of the Arctic.

The objective of this project is to develop a reliable means of predicting these temperatures and to carry out on-board measurements to verify the prediction model. A heat transfer cell representative of a closed, six-sided compartment aboard the M.V. *Arctic* will be used to test and verify the prediction model developed.

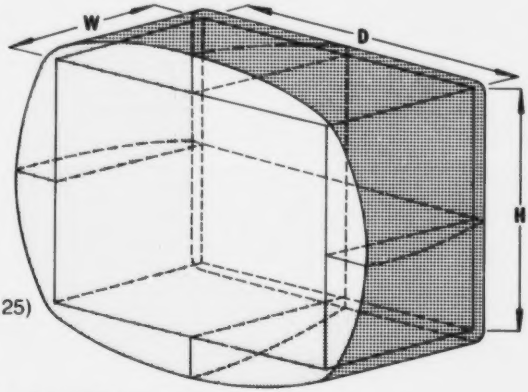
Progress to May 1982

Researchers examined three typical heat transfer cells in three types of ships in the Arctic, using a finite element computer model that can cope with the three-dimensional complexities of ship structures and arrangements. The model includes heat transfer by conduction, convection and radiation. The convection segment of the model uses several approximations, as a fully detailed modelling of the flow pattern proved to be impractical. Structural elements and their pertinent thermal properties were defined in a manner suitable for incorporation in the model. Researchers determined that under some circumstances substantial amounts of heat are transferred by convection and radiation.

Instrumentation was installed aboard the M.V. *Arctic* so that measurements could be taken to verify the model. A test run in the summer of 1981 gave partial verification. Damage to the system terminated the effort before cold weather data could be obtained.

Contractor H.G. Engineering Ltd., Don Mills, Ontario

Report None to date



A heat transfer equation:

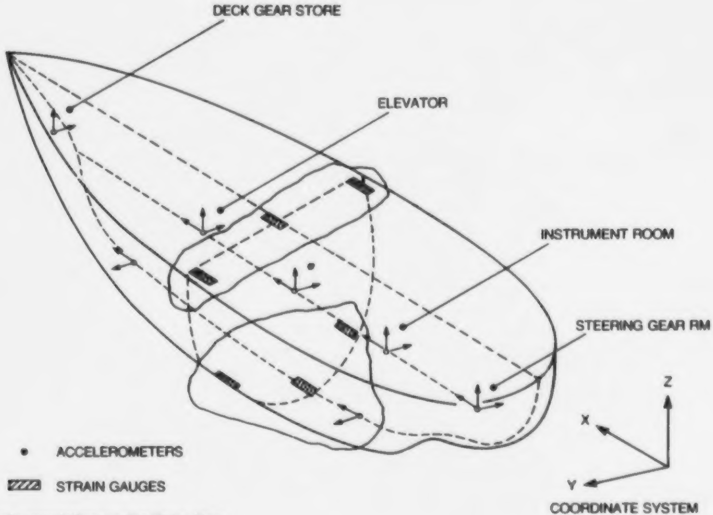
$$h' = h(0.75 \sin \pi^{z}/H \cos \pi^{x}/W + 0.25)$$

Variation of the internal surface coefficients of a typical cell

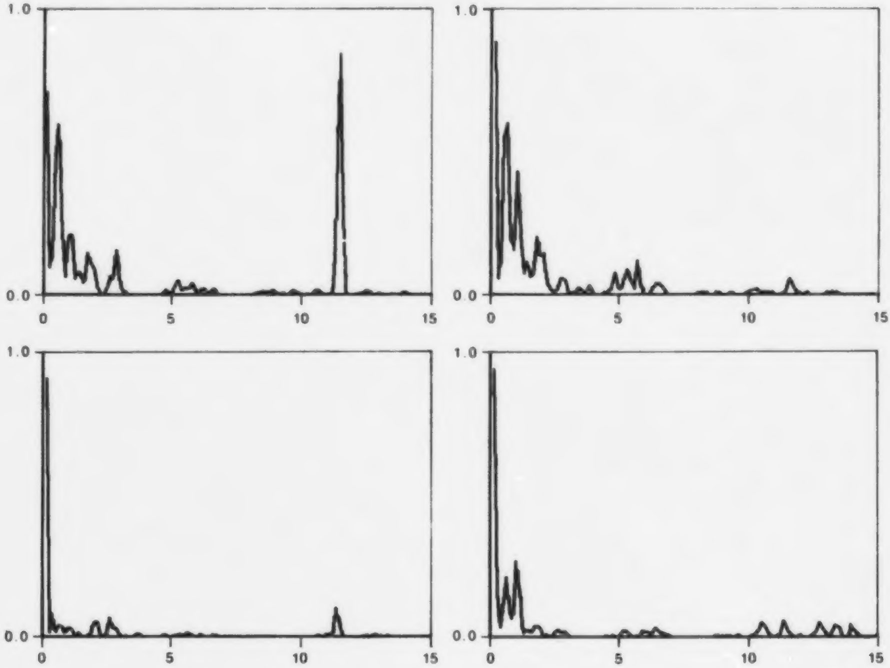
---

Schedule: August 1979 — September 1982
Funding: Energy R&D Panel — $80,000
CMTA-AM — $56,000

Project Number: 8953
File Number: D-1460-129-3
Project Officer: I. Bayly


DECK GEAR STORE
ELEVATOR
INSTRUMENT ROOM
STEERING GEAR RM
Z
X
Y
COORDINATE SYSTEM
● ACCELEROMETERS
▨ STRAIN GAUGES

Locations of instrumentation on the Polar Sea



Instrument readings of hull vibrations induced by ice

Ice-Induced Hull Vibration

Description

Ice-induced structural vibrations have an important effect on the performance of ships in ice. Vibration has implications with respect to stress levels at critical points in the hull itself, and to design specifications for machinery, piping and all on-board equipment. Effective prediction of a potentially severe vibration environment is particularly essential where a nuclear power plant is being considered.

The objectives of the work sponsored by TDC were to measure the form and magnitude of vibrations on the hull of a high-powered icebreaker, and to develop a mathematical model for the icebreaking forces that excite hull vibrations.

Progress to May 1982

This project is complete. The contractor has concluded analysis of data on icebreaker hull vibration collected by a Canadian research team during a U.S. government and oil company sponsored expedition by the U.S. Coast Guard icebreaker *Polar Sea* to Point Barrow, Alaska, in January and February 1981. The contractor also developed a methodology for retrieving the raw data collected during the trials.

The information recorded on magnetic and video tapes includes vertical, athwartship and fore and aft accelerations at various locations within the ship, strain measurements, and ice conditions.

Contractor

Arctec Canada Ltd., Kanata, Ontario

Report

TP 3617, Winter 1981 Trafficability Tests of the USCGC Polar Sea, Volume IX: Ice Induced Vibration Measurements and Development of a Model for Icebreaking Forces, 3 volumes, Arctec Canada Ltd., March 1982.

Schedule: January 1981 — September 1982

Funding: TDC --	$ 80,000
CMTA —	$ 60,000
DSS —	$148,000
Total —	$288,000

Project Number: 4255
File Number: D-1460-158
Project Officer: I. Bayly

Steering System Ice Loads, USCGC *Polar Star* 1982 Arctic Voyage

Description

The objective of this project is to determine the magnitude and characteristics of the loads imposed on steering systems due to ship/ice interactions. To achieve this, the contractor will reduce and analyze Canadian and U.S. records of full scale data concerning ice loads on steering systems, including new data obtained from the March 1982 voyage of the USCGC *Polar Star* to the Arctic. Prior to the voyage the contractor designed and installed instrumentation to measure and record steering system strains, operating parameters and ice conditions.

The recent voyage of the *Polar Star* is one of a continuing series of trafficability studies being carried out by U.S. Coast Guard icebreakers. The scientific effort is sponsored by the U.S. Maritime Administration, with contributions from oil companies, the State of Alaska, and others.

Reliable data on the loads imposed on the steering systems of ships as the result of ice interaction will contribute to the safety, reliability and efficiency of marine traffic in Arctic ice.

Progress to May 1982

The instrumentation installed aboard the *Polar Star* prior to its March 1982 voyage worked well; however, less ice than expected was encountered during the voyage, thus limiting the data collected. Analysis of the data is underway and the final report, including U.S. contributions, is being reviewed.

Contractor

Arctec Canada Ltd., Kanata, Ontario

Report

Draft, Arctic Deployment of USCGC *Polar Star*, Winter 1982, Volume IV: Ice Loads on Steering Gear Systems, Arctec Canada Ltd.

Sister ship Polar Sea *during 1981 Arctic expedition*

Schedule: January 1982 — November 1982
Funding: TDC — $ 15,000
CMTA-AM — $170,000

Project Number: 4532
File Number: D-1460-181
Project Officer: I. Bayly

Ship Manoeuvring Simulation Development

Description

TDC, in consultation with the Canadian Coast Guard, is preparing a long-term research effort in the field of ship manoeuvring simulation, particularly oriented towards the resolution of Arctic navigation problems.

The objective of the current project is to conduct investigative studies into ships operating in ice to help establish the requirements for a ship manoeuvring simulator capable of reproducing ice navigation problems, including those experienced in the Canadian Arctic.

The current work will culminate in a specification for a basic simulator. A detailed breakdown of technology and costs in relation to degrees of realism in ice navigation simulation will also be prepared.

Progress to May 1982

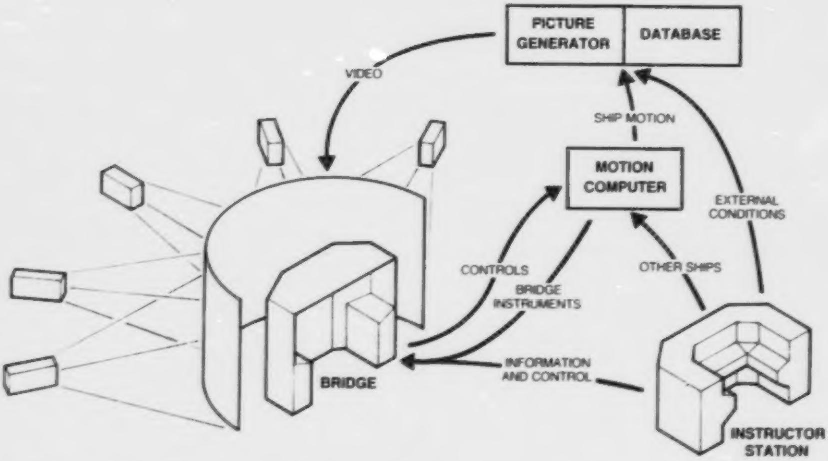
Two questionnaires have been developed. One, designed to gather ice navigation data, has been sent to shipmasters and operators; the second requests information on simulator capability from simulator manufacturers.

Contractor

Arctec Canada Ltd., Kanata, Ontario

Report

None to date


PICTURE GENERATOR
DATABASE
VIDEO
SHIP MOTION
MOTION COMPUTER
EXTERNAL CONDITIONS
CONTROLS
BRIDGE INSTRUMENTS
OTHER SHIPS
INFORMATION AND CONTROL
BRIDGE
INSTRUCTOR STATION

Concept sketch of ship manoeuvring simulator

Schedule: December 1981 — February 1983
Funding: TDC — $71,500

Project Number: 4537
File Number: D-1460-145-1
Project Officer: E. Fisher

Ballast Systems for Ice Navigation

Description

The objective of this project is to establish criteria and practical guidelines for designing, constructing and operating efficient ballast and related fluid-handling systems in ships navigating in cold climates.

In order to operate at efficient draughts, ships frequently add water ballast to replace consumed fuel or discharged cargo. In cold regions water ballast, especially if taken from fresh water sources and contained in tanks exposed to low air temperatures, is subject to freezing, either in the containment tanks or in the interconnecting pipes and valves. Low temperature operation also adversely affects the efficient operation of other fluid-handling processes, such as the engine circulation system and the trimming and heeling tanks in icebreakers. Various design, construction and operating procedures to avoid freezing or its hazardous effects are currently in place, with varying degrees of success. The M.V. *Arctic*, although specifically designed for service in cold regions, has experienced considerable trouble with icing-up of the ballast system.

Work in this project will include:

- review of existing techniques and equipment, and of operators' experiences and problems with ballast and other fluid-handling systems in cold climates;
- review of possible economic solutions in system design, installation and operation; and,
- development of guidelines and recommendations for ship designers, builders and operators.

Progress to May 1982

Information on ballast systems suitable for use in cold temperatures has been assembled and the design guidelines are in preparation. The guidelines include recommendations for special line heaters and valves.

Contractor

Intercan Logistical Services, Montreal, Quebec

Report

Draft, Study of the Redisposition of Ballast Water in Deeply Loaded Ballasted Icebreaking Conditions, Intercan Logistical Services.

Schedule: December 1981 — September 1982
Funding: TDC — $25,000
DSS — $55,000

Project Number: 4316
File Number: D-1460-145-8
Project Officer: E. Fisher

Icebreaking and Ice-Related Research

Much of the effort of the Canadian Coast Guard during the winter season is directed towards combating the influence of ice on marine transportation. In the far north, this effort continues year round. Innovative methods to improve the performance of ice class ships are the subject of several TDC projects. Research currently underway includes:

Air Cushion Icebreaking Bow Evaluation Program: an operational evaluation of an air cushion icebreaking bow.

Analysis of Dynamic Icebreaking by Air Cushion Vehicles: a study aimed at increasing the understanding of how air cushion vehicles break ice.

Integral Fluid Cushion Icebreaking Bow: the enhancement of icebreaker capability through the use of an air or water cushion bow.

Air Cushion Technology Research: the understanding of the icebreaking capability of air cushion vehicles is part of a continuing research program at the University of Toronto's Institute for Aerospace Studies. Of particular interest in the current work is vehicle stability.

SSACV Icebreaking LNG Tanker Feasibility Study: an innovative application of air cushion vehicle technology.

During the past two years, TDC has also sponsored analytical studies of the icebreaking characteristics of conventional icebreakers. In a research project on ship resistance to continuous motion in level ice, Dr. Donald Carter, well-known researcher in the field, studied correlation of ice rupture and hull shape and analyzed designs of icebreaking bows.

Despite advances in Arctic vessel construction, ways to avoid or at least minimize major ice-ship confrontations continue to have high priority among ship operators. Information currently available on sea ice thickness along the eastern seaboard and in the Arctic is inadequate for navigational use. The watch techniques used on ships are effective only under conditions of good visibility. Both shortcomings compound the difficulty of navigating in the far north and add significantly to transportation costs.

Two projects in this section, **Remote Sea Ice Thickness Sensor Development** and **Ice Hazard Detection**, concern the use of sonar sensors and other electronic sensing devices as solutions to this problem.

Air Cushion Icebreaking Bow Evaluation Program

Description

For the past decade Transport Canada has been developing air cushion icebreaking technology in order to improve the overall effectiveness of its icebreaking operations in inland and coastal waters and to permit the application of this technology in the Arctic.

The air cushion vehicle used during the first years of the program was built, with government assistance, for Arctic Systems Limited as a 100-ton capacity Arctic transporter, the ACT-100.

For the first full-scale trials, the ACT-100 air cushion platform was modified to fit the bow of the Canadian Coast Guard's *Alexander Henry*. The trials were conducted off Thunder Bay during the winter of 1975/76. Compared to her "normal" performance, the icebreaker, with the air cushion platform attached, was able not only to break substantially thicker ice, but did so while progressing at higher speeds, using much less fuel and leaving a better track for other ships to follow.

A second series of tests was undertaken in the winter of 1976/77. The objectives of these tests were to demonstrate the commercial application of the air cushion platform and to accumulate additional data on its performance under operational conditions with commercial vessels. These trials showed a threefold improvement in the icebreaking capability of the combination ship and air cushion platform over that of the icebreaker operating alone.

In 1979 the Canadian Coast Guard acquired its own air cushion icebreaking bow (ACIB), built by Hoverlift Systems Limited of Calgary. As the ACIB did not meet all CCG operational requirements, the Coast Guard asked TDC to prepare the craft for testing and carry out tests of the design.

In 1981 the ACIB was moved from Calgary to Thunder Bay, where the preparatory work was completed. In tests conducted late in the 1981/82 season, the ACIB performed more or less identically to the ACT-100 platform in the earlier trials. The later tests also revealed a number of deficiencies in the ACIB design that require correction prior to further testing.

The objective of the current project is to complete the evaluation program of the ACIB so that its operational potential can be fully documented. To do this, essential repairs to the craft will be made and a series of icebreaking trials carried out during the 1982/83 season. These trials will be made with several host ships and over varying ice thicknesses.

Progress to May 1982

TDC has reviewed the findings of the 1981/82 trials and defined a test program for the completion of the evaluation. Major achievements of the 1981/82 work include the design and construction of a new notch seal support structure and the completion of over 100 hours of valuable operating experience with the ACIB.

Contractor

To be determined

Report

TP 1924, Air Cushion Icebreaking Bow Development Program, 1975-1978, Consolidated Report, TDC, March 1980.

Schedule: August 1982 — August 1983
Funding: undetermined

Project Number: 4794
File Number: D-1460-163-14-6
Project Officer: J. Laframboise

Analysis of Dynamic Icebreaking by Air Cushion Vehicles

Description

The dynamic rupture or breaking of ice by an air cushion vehicle (ACV) was first witnessed in 1974 when the Canadian Coast Guard began winter operation with the *Voyageur*.

Since that time the icebreaking capabilities of the *Voyageur* have been exploited but, to date, the operating techniques have developed in a strictly empirical fashion, so that transfer of these techniques to other air cushion vehicles has not been possible. Some attempts at icebreaking with small hovercraft have met with success, but without any real knowledge of the limitations.

The objective of this project is to extend the icebreaking capability to new ACV's by mathematically analyzing the rupture phenomenon. Researchers will study the speed, mass and cushion pressure of hovercraft in relation to ice strength and thickness.

The results of the analysis are expected to provide the optimal dimension and weight of ACV's for given ice covers.

Progress to May 1982

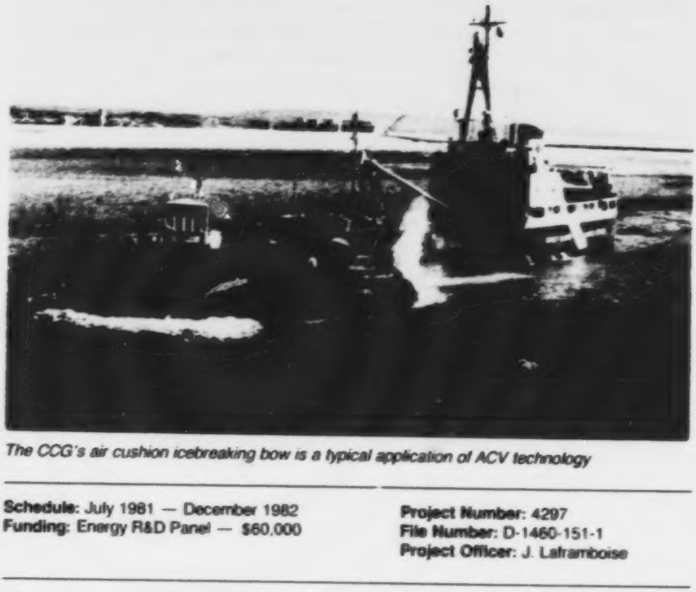
The theoretical analysis has been completed. Design characteristics relating to specific application needs are being developed.

Contractor

Mathematical Consultants Inc., Victoria, British Columbia

Report

None to date



The CCG's air cushion icebreaking bow is a typical application of ACV technology

---

Schedule: July 1981 — December 1982
Funding: Energy R&D Panel — $60,000

Project Number: 4297
File Number: D-1460-151-1
Project Officer: J. Laframboise

Integral Fluid Cushion Icebreaking Bow

Description

Icebreakers are designed to rupture the mechanical structure of ice and disperse the ruptured pieces in such a way as to leave a clear track behind the vessel. Essentially, an icebreaker ruptures ice by applying vertical force. As a result of the angular contact of the ship's hull with the ice and snow, this vertical force induces a drag force, which determines the required propeller thrust. An effective icebreaker is thus one that maximizes the ratio between the applied vertical force to the available thrust. This ratio is termed the Hull Transform Ratio (HTR).

Experience with icebreakers and air cushion icebreaking bows (ACIB) has shown that the HTR values of the former are approximately one, while those of the ACIB may be as high as 20.

Tests in uniform ice have shown that air cushion icebreakers can be 90 per cent more fuel efficient than conventional icebreakers. But present air cushion icebreakers cannot be used in the Arctic because of the numerous ridges that must be traversed by ramming. TDC is studying plans for a multi-phase program to develop an integrated fluid (air or water) cushion bow that would provide the efficiency advantages of air cushion icebreaking in uniform ice cover and permit the ramming essential for operation in the Arctic. Fluid cushion technology would not only benefit icebreaking operations, but would also be applicable to commercial ships.

The objective of this project was to determine the feasibility of the concept through a theoretical investigation of the icebreaking process and the interaction of the fluid cushion bow with the ice cover.

Progress to May 1982

This project is complete. Each contractor has prepared concept definitions for an integral fluid cushion icebreaker. These are now under review by TDC.

Contractors

German & Milne Inc., Montreal, Quebec
Canfin Arctic Consultants Ltd., Pointe Claire, Quebec
Davis Engineering Ltd., Ottawa, Ontario

Reports

TP 3407E, Concepts for the Integration of a Fluid Cushion into the Bow of a Ship, German & Milne Inc., January 1982.
TP 3406E, Concepts for Icebreakers with Integral Air Cushion Bow, Canfin Arctic Consultants Ltd., December 1981.
TP 3405E, Concepts for Icebreakers with Integral Fluid Cushion Bow, Davis Engineering Ltd., December 1981.

Schedule: July 1981 — December 1981
Funding: Energy R&D Panel — $52,000

Project Number: 4454, 4455, 4293
File Number: D-1460-149-1
Project Officer: J. Laframboise

Air Cushion Technology Research

Description

The University of Toronto's Institute for Aerospace Studies (UTIAS) was established in 1970 as a "centre of excellence" to undertake research in support of Canadian industry and government activities in air cushion technology. Air cushion facilities at UTIAS include a circular test track and dynamic heave table test equipment.

TDC has provided financial support of the UTIAS research for the past five years so as to provide continuity of specialized investigations. The lines of inquiry followed, each of which developed and extended past work at UTIAS and was related to Canadian industry, were:

- Investigation of the dynamic behaviour of air cushion skirt systems through the use of scale models. Tests were conducted on the UTIAS circular track and other existing test stands. This investigation examined the Hoverlift Systems Ltd. skirt system. The project defined the operational limits of this system and compared it with multicellular cushion systems.
- Investigation of dynamic instabilities and damping in air cushion systems. This work addressed the pneumatic circuit of the air cushion and comprised several studies into the effect of specific components on overall stability.

The objective of current work is to investigate damping mechanisms, passive and active, that can forestall the pneumatic heave instability of large air cushion vehicles of the type under consideration as icebreakers in the Arctic.

Progress to May 1982

Researchers are now studying the phase relationship between heave motion and pressure oscillation of the vehicle. Study findings to date indicate that the onset of instability can be related to a specific value of the phase relationship.

Contractor

University of Toronto, Institute for Aerospace Studies, Toronto, Ontario

Reports

Draft, (1979) Research on Air Cushion Stability, University of Toronto, Institute for Aerospace Studies.

TP 1760, Research on Air Cushion Stability, University of Toronto, Institute for Aerospace Studies, October 1978.

Schedule: November 1981 — March 1984
Funding: TDC — $249,454

Project Number: 7479, 4481
File Number: D-1460-125-2
Project Officer: J. Laframboise

SSACV Icebreaking LNG Tanker Feasibility Study

Description

The waves formed by a ship's hull and their interference with the ship's progress would be significantly reduced if the hull ran below the water surface. Various concepts of cargo ships with such hulls have evolved, ranging from a pure submarine to the semi-submersible, a craft whose hull is largely submerged. For better stability, twin-hull versions of the semi-submersible with a flat deck uniting the two hulls have been designed. An air cushion added to this configuration would carry part of the vessel's load, as dictated by weight and speed conditions; it would also increase the craft's stability and provide ice transiting capability similar to that of an air cushion icebreaking bow.

The objectives of this study were to determine whether an SSACV can provide improved Arctic transportation and to provide insight on the problems involved in the design and construction of the large air cushion tankers contemplated for Arctic operation.

Progress to May 1982

This project is complete. Costs of construction and annual maintenance, and manning and speed in open water and ice were compared for an SSACV icebreaking LNG tanker and a monohull LNG tanker with the same capacity and power.

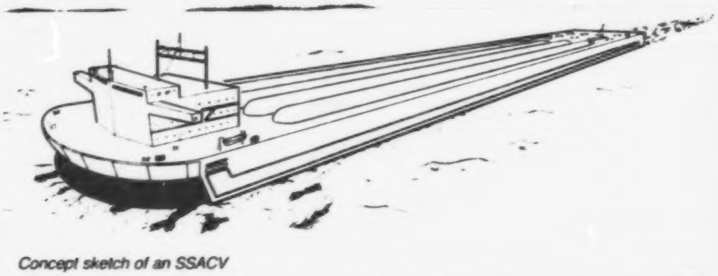
The project report concludes that while the SSACV icebreaking tanker offers considerable improvement over a monohull design in operations in smooth ice of uniform thickness, it does so with higher capital and operating costs as well as with the complications introduced by the air cushion. It was also found that when the twin-hull ship was operated with the air cushion in the off position, ice transiting performance was impressive, although below the performance with the air cushion on. The practical problems involved in designing, operating and maintaining a large SSACV with the characteristics required for Arctic winter conditions are formidable. Further testing is required before it would be possible to say whether the SSACV icebreaking tanker is a feasible proposition.

Contractor

German & Milne Inc., Montreal, Quebec

Report

Draft, SSACV Icebreaking LNG Tanker Feasibility Study, German & Milne Inc.



Concept sketch of an SSACV

Schedule: April 1981 — March 1982
Funding: TDC — $15,000

Project Number: 4271
File Number: D-1460-157-1
Project Officer: J. Laframboise

Remote Sea Ice Thickness Sensor Development

Description

A requirement exists for an all-weather airborne instrument to measure the thickness of sea ice. Such a sensor would be an asset to the Canadian Coast Guard on its icebreaker helicopters and to the Atmospheric Environment Service on its Electra ice patrol aircraft. The ability to obtain information on the distribution and thickness of sea ice along the eastern seaboard and in the Arctic would facilitate navigation and extension of the shipping season and improve ship safety.

In the first phase of this project, researchers determined that the most suitable concept for an airborne remote measuring sensor was a combined synthetic pulse/impulse radar. They designed and built experimental radar equipment and tested it in the Beaufort Sea in April 1980. The Arctic tests verified that the signals used can penetrate sea ice to an adequate depth, and that the same antenna can be used for both synthetic pulse and amplitude modulated radar signals. The sensor proved to be suitable for measuring both thin and thick ice, and meaningful measurements were obtained despite the influences of various physical phenomena (e.g. electronic transients, ice dispersion).

In the current phase of the project, researchers are developing an operational prototype for field testing. To this end, they will refine the design of the RF (radio frequency) unit and feed its output to a data processor to obtain digital readouts of ice thickness. They will also design a new antenna that will be a fixed structure mounted between the struts of a helicopter.

Progress to May 1982

The design of the RF unit has been modified and the unit is being constructed. The new antenna has been constructed and readied for installation on a helicopter. It is awaiting airworthiness approval before undergoing operational tests.

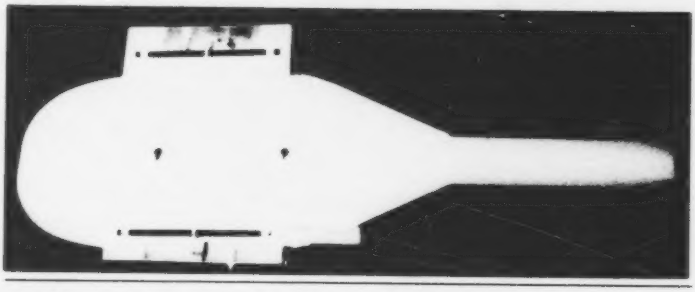
Contractor

MPB Technologies Inc., Montreal, Quebec

Reports

TP 3341, Radio Frequency Circuit Design for Automatic Data Processing of Radar Signals of Remote Sea-Ice Thickness Sensor, MPB Technologies Inc., November 1981.

TP 2857, Evaluation of Options for the Processing of Sea-Ice Thickness Radar Measurements, MPB Technologies Inc., December 1980.



Experimental set-up for testing antenna/aircraft interaction at scaled frequencies

Schedule: August 1978 — December 1982
Funding: TDC — $230,000
Energy R&D Panel — $300,000

Project Number: 4232, 4242
File Number: D-1460-126-5
Project Officer: M. Audette

Ice Hazard Detection

Description

The purpose of this project was to develop an effective technique for ships to detect and avoid ice hazards under all environmental conditions. Such a technique is vital to the safe and efficient sea transport of oil and gas resources from northern Canada.

At present, ships operating in ice-infested waters rely basically on watch observers to spot ice hazards. Visual sighting, however, is ineffective at night and in poor weather.

Little is known about the ice-detecting capability and reliability of electronic sensors, such as radar, sonar, infra-red and low light level television. Activities for this project included a theoretical evaluation of the performance of these sensors and an extensive field evaluation in the north Baffin Bay/Lancaster Sound area during the summer of 1980.

The information collected on the performance of equipment of current design will serve as a data base for the development of improved sensors. These sensors will then be integrated into an automatic, computer-controlled ice warning and collision avoidance system capable of displaying ice hazard warnings on the bridge of a ship.

Progress to May 1982

This project is complete. The sensors were installed aboard the *Polarhav* and the field evaluation program was conducted in the vicinity of Lancaster Sound and Jones Sound during the summer of 1980. Data were collected on the performance of the sensors in detecting ice hazards ranging from growlers weighing 100 tonnes to major icebergs of 100 million tonnes or more at various ranges and under all weather conditions.

The results indicate that radar and infrared sensors can detect ice hazards in open water, at various ranges and under a variety of environmental conditions. But their detection capability and reliability in severe weather and environmental conditions (such as high seas and heavy precipitation) was only marginal.

The study concludes that a detection system of two or more sensors would have greater range, capability and reliability than any single sensor.

Contractor

Petro Canada Explorations Inc., Calgary, Alberta

Report

Temporarily non-releasable at request of contractor

Schedule: March 1980 — March 1982

Funding: TDC —	$ 100,000
Petro Canada Explorations —	$1,350,000
Energy R&D Panel —	$ 500,000
DSS —	$ 500,000
Total —	$2,450,000

Project Number: 4053, 4107, 4108
File Number: D-1460-146-1
Project Officer: M. Audette

Marine Transportation Systems

TDC research in this area is directed towards increasing the efficiency, flexibility and hence productivity of shipping operations in the Arctic, the Great Lakes, the St. Lawrence Seaway and other Canadian waters.

Several projects relate to port operations. These include:

Demonstration of Harbour Ice Management Techniques: the study of air displacement of warmer deep water to control dockside build-up of ice, thus ensuring dock accessibility at the opening of the navigation season.

Ice Control for Arctic Ports and Harbours: an investigation of alternative methods to extend the shipping season in the Arctic and in the Great Lakes.

Archimedean Screw Tractor Evaluation: a vehicle equally at ease in ice and water and with potential as a harbour ice management tool.

Concrete Paving Blocks for Marine Terminals: a comparative evaluation of the use of concrete blocks and asphalt in terminals.

Other projects relate to increased productivity in marine operations. These include:

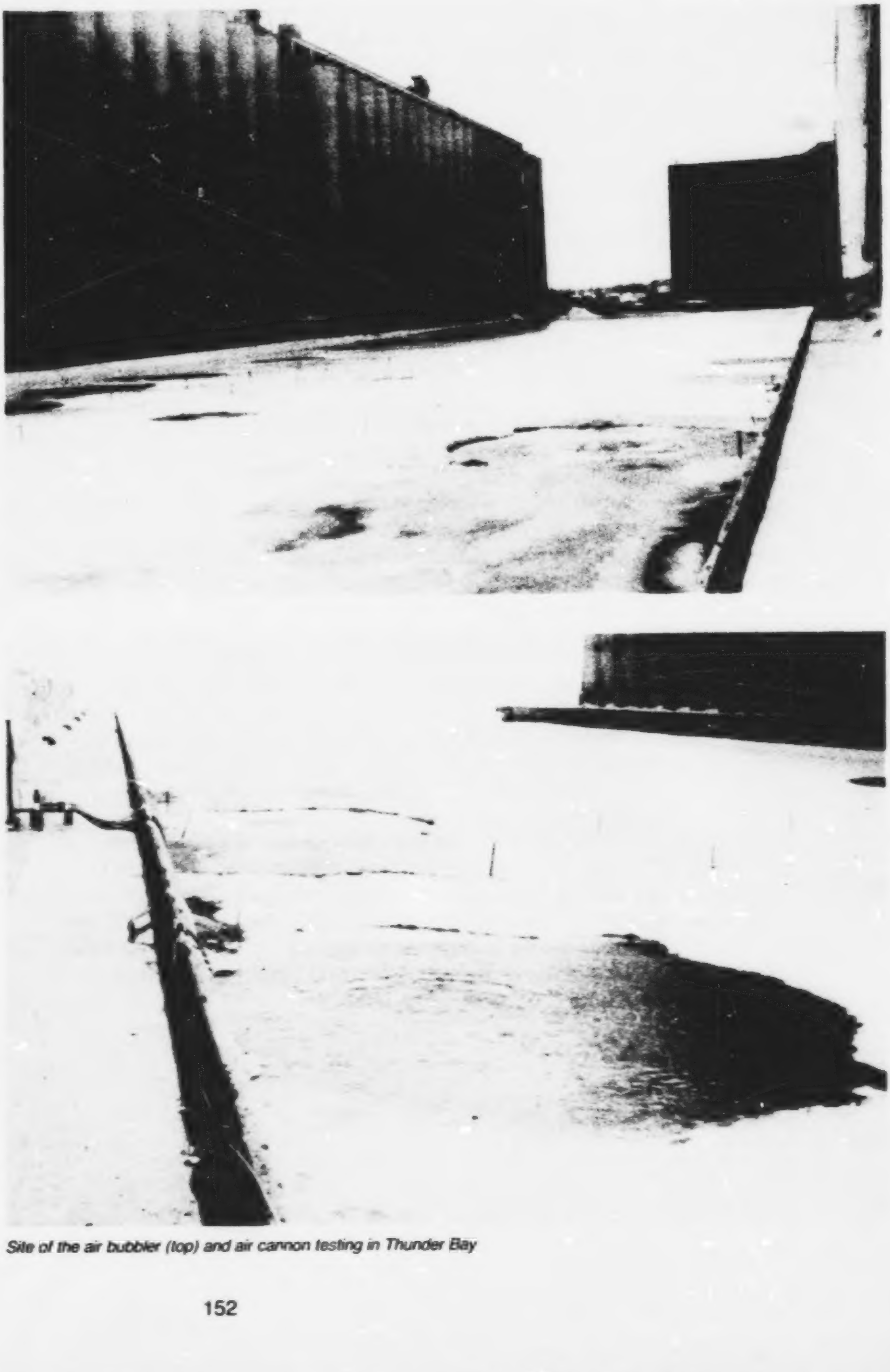
Engine Health Monitoring System: this work responds to a need to reduce maintenance costs and downtime of marine propulsive systems.

Hydrostatic Stern Tube Bearing: an innovative development to extend the life of stern gear.

Development of a Low Resistance Barge: a study to increase the fuel efficiency of the towing vessel.

Underwater Inspection System Development: the application of video technology to overcome the difficulties and reduce the costs of using divers for underwater inspection.

TDC is also supporting the development of a **Quasi-Doppler Marine VHF Radio Direction Finder**, an improved VHF radio direction finder using modern, less costly components. In addition, TDC is conducting a **Wave Climate Study** to develop a methodology for relating wind and wave climatology in Arctic and offshore regions to structural design.



Site of the air bubbler (top) and air cannon testing in Thunder Bay

Demonstration of Harbour Ice Management Techniques

Description

The aim of this project is to extend the Great Lakes shipping season by eliminating the ice barriers that impede access to port loading berths. One method of controlling the formation of ice in loading berths is to push warm water from beneath the ship to the surface. Two systems, a bubbler and an air cannon mixer, have been used to do this.

An air bubbler system is simply a submerged perforated pipe through which compressed air is blown. The rising air bubbles cause the water above the pipe to circulate, thereby bringing the warmer water from lower depths to the surface to melt the ice. An air cannon mixer accumulates air then releases it periodically in the form of a single large bubble that acts as a piston to push the warm water to the surface.

This project is expected to provide detailed information on the cost effectiveness of the air bubbler and air cannon mixer systems for ice control.

TDC sponsored the installation and operation of an air bubbler system at the Saskatchewan Wheat Pool's grain elevator No. 7 loading berth at Thunder Bay harbour. Thickness of ice in this loading berth and an adjacent berth was monitored throughout the 1979/80 and 1980/81 operating seasons. Experiments were also conducted with the bubbler using a low cost blower, instead of the compressor, but this substitution proved to be impractical. The experiments concluded that while the air bubbler was effective in controlling ice formation, it was prone to damage from the propeller wash of ships.

TDC also commissioned a similar demonstration using an air cannon mixer during the 1981/82 season at the Canada Malting Wharf in Thunder Bay. The air cannon mixer has the advantage of operating on air blowers, which are less costly to operate than compressors.

Progress to May 1982

Both the air bubbler and the air cannon mixer were in operation during the 1981/82 season. The bubbler system again sustained damage due to the propeller wash from ships, while the air cannon was unaffected. It appears that a combination system will be most effective. Detailed reports on both demonstrations are in preparation.

Contractors

Lakehead Harbour Commission, Thunder Bay, Ontario
Atara Corporation, Montreal, Quebec

Subcontractor

V.B. Cook Co. Ltd., Thunder Bay, Ontario

Reports

Draft, Evaluation of the Atara Piston Bubbler Cannon Mixer for Ice Suppression in Thunder Bay, Ontario, V.B. Cook Co. Ltd.
Draft, Air Bubbler Ice Control Experiment in Thunder Bay, Ontario, V.B. Cook Co. Ltd.
TP 2657, Air Bubbler Ice Control Experiment in Thunder Bay, Lakehead Harbour Commission, May 1980.

Schedule: January 1981 — July 1982
Funding: TDC — $15,000
CMTA — $85,000

Project Number: 4268, 4269, 4563, 4600
File Number: D-1460-145-2
Project Officer: L.A. McCoomb

Ice Control for Arctic Ports and Harbours

Description

The objective of this project is to identify and evaluate alternative techniques for maintaining Arctic ports and harbours open to navigation for extended or year-round operation and for protecting their facilities from ice damage.

Ice in Arctic ports and harbours presents a special problem because the constant passage of ships in the confined waters of northern ports leads to massive build-ups of ice. These ice accumulations not only restrict navigation at the end of the season, but also delay the resumption of navigation at the beginning of the new season. Moreover the ice forces, both natural and ship-induced, can cause significant damage to port structures. Various harbour ice control techniques have been proposed and tested; these must now be reviewed and their cost-effectiveness in potential Arctic and Great Lakes ports applications evaluated.

The project work includes an extensive literature search to determine the nature of the ice control problem and identify corrective techniques — current and proposed. An inventory of all identified ice management techniques is also planned and will include a detailed engineering description of each technique, its unit cost, estimates of effectiveness, range of applicability and, wherever possible, studies of actual installations.

Following this, evaluation criteria will be developed, against which each ice management method will be assessed. The project report will take the form of a reference manual for engineers researching ice control techniques for ports and harbours in the Arctic or the Great Lakes.

Progress to May 1982

The literature search has been completed and work on the inventory of ice management techniques is underway.

Contractor

Acres Consulting Services Ltd., Toronto, Ontario

Report

None to date

Schedule: January 1982 — December 1982
Funding: TDC — $20,000
CMTA AM — $59,000

Project Number: 4524, 4526
File Number: D-1460-14-5
Project Officer: L.A. McCoomb

Archimedean Screw Tractor Evaluation

Description

The Archimedean screw tractor or AST is a vessel that can operate in solid or broken ice and in open water. It is supported and propelled by rotating helical screws located along its sides.

The objective of this project is to evaluate the cost effectiveness of the AST as an ice management tool.

In March 1982, an AST was used to prepare snow and ice surfaces near and around the Cargill Elevator loading slip in Thunder Bay so as to accelerate normal ice melt. Plots of ice, 50 m x 100 m, were prepared in various ways, e.g. snow cleared, surface roughened, trenched or dusted with albedo material to reduce ice reflectivity coefficient. Control plots were designated for comparative purposes.

The AST was then used in the monitoring of the changing ice thicknesses and strength of each plot. During the test period, the AST also served as a winter port service vessel in support of air cushion icebreaking tests at Thunder Bay. Its own capabilities as an icebreaker were also measured.

Results of this work will be used in support of continuing efforts to extend the shipping season on the Great Lakes.

Progress to May 1982

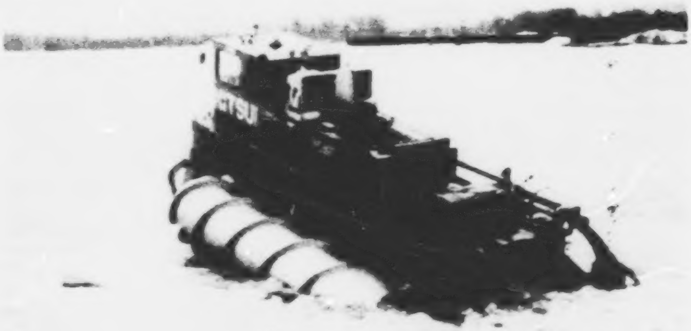
This project is complete. The report documents the varying effects surface treatment has on ice melt rates. The versatile AST appears to be significantly effective for harbour ice management. In its present design, it is very slow in open water operations, relying solely on the helical screws for propulsion. It is expected that newer models will include a propeller for open water use.

Contractor

Arctec Canada Ltd., Kanata, Ontario

Report

Draft, Evaluation of Archimedean Screw Tractor for Ice Management, Arctec Canada Ltd.



Archimedean screw tractor

Schedule: March 1982 — April 1982
Funding: TDC — $45,000

Project Number: 4583
File Number: D-1460-145
Project Officer: L.A. McCoomb

Concrete Paving Blocks for Marine Terminals

Description

The objective of this project is to examine the comparative economic and performance advantages of using concrete paving blocks instead of asphalt or concrete paving for heavy duty applications in marine terminals.

Modern cargo handling equipment, particularly the new machines designed to move containers, can impose heavy loadings on port terminal pavements, resulting in rapid deterioration of surfaces and high operating and maintenance costs. In Europe, concrete block paving materials, which combine the flexibility of asphalt type pavement with the strength and oil resistance of rigid concrete pavement, are in common use.

The first phase of this project reviewed international experience with concrete block pavements in heavy duty port applications. A detailed comparative economic analysis of concrete block pavement and other types of pavement was also made. The second phase includes identifying objectives for field trials of concrete paving blocks in port applications, designing a test program and installing and monitoring two test sections at the Port of Montreal.

The results of this work will provide an evaluation of concrete block pavements under actual operational and environmental conditions in a Canadian port.

Progress to May 1982

Concrete block pavement was installed at the Racine and Task terminals at the Port of Montreal. These blocks have been in place for several months. Evaluation of their performance will continue for one year.

Contractors

National Harbours Board, Ottawa, Ontario
Canadian Marine Transportation Administration, Ottawa, Ontario
Centre de recherche et de contrôle appliqué à la construction Inc., Montreal, Quebec

Report

None to date

Concrete paving blocks under test at the Port of Montreal

Schedule: November 1981 — March 1983
Funding: TDC — $150,000

Project Number: 4464, 4519, 4544
File Number: D-1465-346
Project Officer: L.A. McCoomb

Engine Health Monitoring System

Description

The purpose of this project is to develop an integrated, automatic equipment health monitoring system so as to reduce maintenance costs and equipment downtime and to improve the overall performance of marine propulsion engines.

The marine industry spends considerable sums on vessel maintenance that is conducted either at predetermined time intervals or simply when equipment breaks down. Other transportation industries base their maintenance policies on the actual operating condition of equipment, determined with the aid of equipment monitoring devices. These devices, however, are often uneconomical, are not designed for the marine environment, and do not fully exploit the state of the art to provide an integrated equipment health monitoring and diagnostic system.

The objectives of this project are to conduct a feasibility study of such a system, using modern techniques, such as regression and correlation theory; to investigate and identify those measurable parameters of a diesel engine that would provide meaningful engine health/condition information; and, to determine the most cost-effective method of instrumenting an engine to obtain the required data for input to a suitable computing and display system.

Progress to May 1982

The feasibility study outlines several promising alternatives for an engine health monitoring system. TDC is reviewing the results of the study.

Contractor

Eyretechnics Ltd., Ottawa, Ontario

Report

Draft, Feasibility Study for the Development of an Engine Health Monitoring and Diagnostic System, Eyretechnics Ltd.

Schedule: January 1982 — June 1982
Funding: TDC — $36,000

Project Number: 4447
File Number: D-1460-176-1
Project Officer: R.H. Dillon

Hydrostatic Stern Tube Bearing

Description

The objective of this project is to improve the reliability and safety of ships operating in the Arctic by improving the performance of the propeller stern tube bearing. This bearing supports the propeller shaft as it passes through the hull of the ship. Normally located adjacent to the propeller, the stern tube bearing is very highly loaded and slow turning.

Wear down and destruction of conventional hydrodynamic bearings is increasing because of insufficient hydrodynamic film supporting the heavy propeller/screw shaft assemblies of modern ships. A hydrostatic or externally pressurized bearing offers a solution to this costly problem. In such a bearing the shaft is not supported by hydrodynamic film, but rather has the journal pressurized clear of the bearing at all times.

For this project the contractor will manufacture a 6 1/2-inch (16.25 cm) diameter model of a hydrostatic stern tube bearing and test it in a laboratory under simulated service conditions. This model would represent in 1:5 scale the bearing of a modern supertanker. The testing will include vibratory and eccentric thrust effects. If the test results prove satisfactory, a full-scale bearing will be installed in a ship for further evaluation.

Progress to May 1982

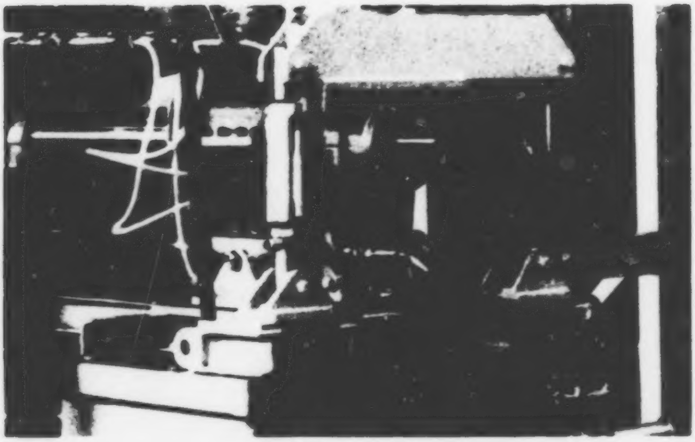
The construction of the test-rig is nearing completion. Testing, to be conducted in the facilities of the Naval Engineering Test Establishment of the Department of National Defence in Montreal, is expected to start in September.

Contractor

Peacock Inc., Montreal, Quebec

Report

None to date



Hydrostatic stern tube bearing under test at the Naval Engineering Test Establishment

Schedule: July 1981 — January 1983
Funding: CMTA-AM — $363,000

Project Number: 4474
File Number: D-1460-162
Project Officer: R.H. Dillon

Development of a Low Resistance Barge

Description

The objective of this project is to develop a low resistance barge hull form optimized for course stabilization with high performance skegs. The target is a stable towing barge hull and skeg combination of specific resistance about 1.5 times that of a comparable "Series 60" ship hull form. This would represent a 25% decrease in the specific resistance of current barge hulls.

Development of a low resistance barge form is economically desirable as fuel costs increasingly tip the economic balance away from simpler hull forms, which are less expensive to build, yet more costly to operate. Successful application of a high performance skeg to stabilize a low resistance hull form would be an innovation that responds to this major problem in barge design.

The first phase of this project consisted of parametric studies based on past operational experience and predicted future requirements. Cargo and outfit requirements were taken into account, along with market, port, and environmental factors. Optimized lines plans and skeg configurations were developed for models to be built in the second phase of the project.

For phase two, a series of models with interchangeable bow, stern, and mid-body sections was constructed to permit testing of eight hull forms suitable for different service applications. Some rough water tests were also included. Testing was carried out by the B.C. Research Ocean Engineering Centre.

The current work represents the third phase of the project. For this phase capital expenditure alternatives will be analyzed in conjunction with resistance results to arrive at the most cost-effective design. A preliminary structural arrangement, skeg design, and specification package will be prepared for a shipbuilding tender, which will provide a correlation point for cost estimates.

Throughout the work particular attention has been directed towards the proprietary "Hydrolift Skegs" developed by Seaspan Development Company Ltd. of Vancouver. These skegs are claimed to provide stable towing of conventional barges with a substantially smaller increase in resistance than occurs with conventional skegs.

Progress to May 1982

The resistance data and the stability parameters for each of the models tested in phase two have been reduced for ready reference. A report is being prepared.

Contractor

Seaspan Development Company Ltd., Vancouver, British Columbia

Report

None to date

Schedule: February 1982 — May 1982
Funding: TDC — $30,000
Seaspan Development Co. Ltd. — $30,000

Project Number: 4592
File Number: D-1460-180
Project Officer: I. Bayly

Underwater Inspection System Development

Description

The objective of this project is to develop and perfect a remote-control video camera system for underwater inspection of wharves and other submerged port structures.

The use of a diver is the most common method of conducting these inspections. But this method has several disadvantages: it is labour-intensive, time consuming and hence costly; and, working conditions are difficult (e.g. strong currents, excessive cold), resulting in inaccurate damage estimates and ineffective maintenance planning. A lateral sweep sonar has been suggested, but the data would be difficult to read and interpret.

A video camera towed underwater by a boat would provide a complete and accurate visual record of the condition of inspected structures. It would also eliminate in great part the need for divers, substantially reducing labour costs. The camera would be aligned with the boat's navigation equipment to permit keying the video pictures to precise locations.

Progress to May 1982

The camera attachment mechanisms have been fabricated and the camera case checked and verified for watertightness. The system is currently under test in the Port of Montreal. If the trials are satisfactory, the next phase will involve a detailed economic assessment.

Contractor

Pelchat Grenier Géomarine Inc., St. Hubert, Quebec

Report

None to date

Video camera module for underwater damage surveys

Schedule: March 1982 — July 1983
Funding: TDC — $12,500

Project Number: 4708
File Number: D-1460-183
Project Officer: S. Corbeil

Quasi-Doppler Marine VHF Radio Direction Finder

Description

The objective of this project is to develop and build a new state of the art marine doppler radio direction finder that will be more accurate and reliable yet less costly than current models.

The doppler radio direction finder (RDF) has long been recognized as a practical aid for coastal navigation. Transport Canada's air and marine administrations make extensive use of radio direction finding in traffic control and search and rescue operations.

Bayly Engineering Ltd. recently developed a new doppler RDF in the 117.5 to 137.5 MHz band for use in air traffic operations. For the current project this Canadian firm will build on the experience gained with the air traffic control RDF to develop a quasi-doppler marine VHF radio direction finder in the marine radio frequency band of 156 to 174 MHz. While the design of the marine traffic control unit will be similar to that of its air traffic control counterpart, the requirements for location accuracy are greater in marine operations.

The results of this work will not only provide an improved and less costly RDF for marine traffic control, but will also contribute to the development of a complete range of modern VHF radio direction finders for Transport Canada.

Progress to May 1982

Work has started on the design of a special 32-element antenna array. Subsystem elements for the marine equipment have been designed. These include receiver front end circuits, frequency synthesizers, operator display and controls, and bearing processor software for the antenna. A prototype is being assembled.

Contractor

Bayly Engineering Ltd., Ajax, Ontario

Report

None to date

Schedule: December 1981 — December 1982

Funding: Energy R&D Panel —	$161,000
CMTA-AM —	$ 16,000
Bayly Engineering Ltd. —	$ 30,000
Total —	$207,000

Project Number: 4451
File Number: D-1465-133-2
Project Officer: N.E. Rudback

Wave Climate Study

Description

The objective of this project is to develop a methodology for relating wind and wave climates in Arctic and offshore regions of Canada to structural design criteria for ships and other floating structures.

A previous TDC project on the extension of the operational range of Great Lakes vessels in the Gulf of St. Lawrence addressed the definition of the regional wave climate and related it to structural strength requirements for vessels. A sequel to this study, the current project aims at defining in general terms the techniques involved for application to any Canadian maritime region.

Researchers will conduct literature searches and interviews to:

- identify and classify methods of collecting and recording wind and wave data in Canadian maritime regions;
- identify the state of the art worldwide in wind and wave hindcast procedures; and,
- describe current techniques for relating motions and stresses experienced by ships and other floating structures to wave climates.

Researchers will then evaluate the data gathered so as to develop a suitable Canadian-based strategy for establishing structural design requirements for marine vessels, including fishing boats and small craft, and other floating structures, in relation to regional wave climates.

Progress to May 1982

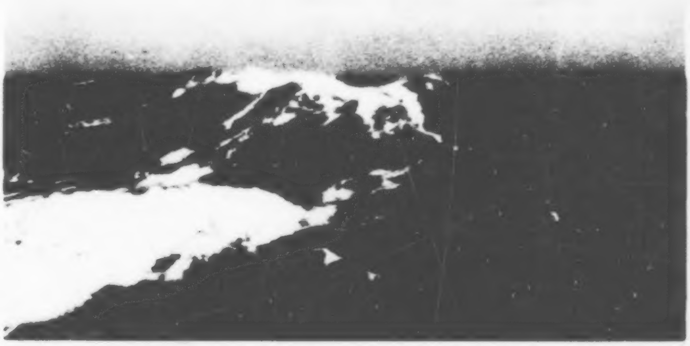
This project has just started.

Contractor

W.F. Baird and Associates, Ottawa, Ontario

Report

None to date



Schedule: April 1982 — March 1984
Funding: CMTA-AM — $13,000

Project Number: 4556
File Number: D-1460-140
Project Officer: E. Fisher

Report Listing

Railway Technology **164**

Surface Technology **172**

Air Technology **187**

Marine Technology **191**

Multimodal Technology **196**

Transportation for the Mobility Handicapped **198**

Other **201**

Report Listing

Railway Technology

1971 - 1973

☒ Alleviation of detrimental frost heave with salt additives, annual report no. 1, by R.N. Yong and D.E. Sheeran, McGill University, Geotechnical Research Centre.

☒ The Barrie-Toronto trial commuter rail service, by R.P. Triffo, TDA.

☒ Testing of bridges at mileages 1.7 and 31.4 of the Shuswap Subdivision, by Canadian Pacific Limited, Department of Research.

1974 - 1976

☒ Alleviation of detrimental frost heave with salt additives, annual reports no. 2 and 3 - 2 volumes, by R.N. Yong and D.E. Sheeran, McGill University, Geotechnical Research Centre.

☒ Arctic oil and gas by rail — 6 volumes, by Canalog Logistics Limited.

Canadian railway electrification study - phase I, 2 volumes, by E.R. Corneil, C.E. Law, R.W. Lake, Canadian Institute of Guided Ground Transport.

☒ Canadian railway electrification study - phase I, Overview, by E.R. Corneil, C.E. Law, R.W. Lake, Canadian Institute of Guided Ground Transport.

☒ Development of an AC motor propulsion system for rail applications, by S.A. Rosenberg et al., TDA. TP 232

☒ Development of a design for a computer model to study derailment in railway grade crossing collisions, final report, by D.B. Cherchas, ENDEV Limited. TP 1077

☒ Evaluation of Algoma Cr-Mo rail steel for Canadian Pacific Limited, interim experimental results, by Algoma Steel Corporation. TP 2389

☒ LRC: the comfort side, by MLW Industries. TP 840

☒ LRC, by M.N. Wadhwani, MLW Industries, Dominion Foundries and Steel Ltd., and Alcan Canada Products Ltd.:

- stage I: Report on the testing and evaluation of LRC equipment operating under existing mainline limits. TP 841
- stage II: Test report on performance of the prototype LRC locomotive and coach at the U.S. DOT/FRA High Speed Ground Test Centre, Pueblo, Colorado. TP 842
- stage III: Report on evaluation of the LRC equipment in daily revenue operation in CNR Tempo service. TP 843

☒ LRC: a summary report on project development and current status of LRC passenger train, by MLW Industries, Alcan Canada Products Ltd. and Dominion Foundries and Steel Ltd. TP 838

☒ LRC: mainline running of the LRC under winter conditions from Avondale, Colorado, to Hamilton, Ontario, and truck inspection at Dominion Foundries and Steel Ltd., Hamilton, Ontario, by MLW Industries. TP 839

Titles preceded by the symbol ☒ designate reports that are out-of-print. Paper copies of these reports may be obtained at a charge of 20¢ per page from the Transport Canada Library and Information Centre, Transport Canada Building, Ottawa, Ontario K1A 0N5. Out-of-print reports dated 1971 to 1978 are available on microfiche for $2.50 each from the Library and Information Centre. Those dated 1979 and onwards are available on microfiche for $5.00 each from Micromedia Ltd., 144 Front Street West, Toronto, Ontario M5J 1G2.

☒ Montreal yard computerized inventory system: application of a mini computer, cathode ray tubes and automatic car identification to maintain freight car inventory in a major railway terminal, by Canadian National Railways.

☒ Montreal yard perimeter automatic car identification system: supplement, by Canadian National Railways.

☒ National transportation policy study: a survey of rail passenger transportation, by Queen's University, Canadian Institute of Guided Ground Transport.

☒ Railway capacity trade-off study, by Management Analysis Center Inc.

☒ Stresses and deformations in railway track, by G.P. Raymond et al., Queen's University, Canadian Institute of Guided Ground Transport.

☒ A study of stresses and deformations under dynamic and static load systems in track structure and support, by G.P. Raymond et al., Queen's University, Canadian Institute of Guided Ground Transport.

Track/train dynamics - phase I, by Department of Research, Canadian Pacific Limited.

Track/train dynamics - phase I, final report, by R.P. Rennie, Canadian National Railways.

Track/train dynamics - phase II, by Canadian National Railways.

☒ Use of resilient fastenings for wood ties as an alternative to concrete ties: an economic comparison, by F.E. King, Canadian National Railways.

1977

☒ Budd rail diesel car modernization study - 7 volumes. TP 844:
  vol. 1: Summary report, by Canadian Pacific Consulting Services Ltd.
  vol. 2: Propulsion system comparisons, by Canadian Pacific Consulting Services Ltd.
  vol. 3: General car improvements, by Canadian Pacific Consulting Services Ltd.
  vol. 4: Garrett gas turbine propulsion system retrofit, by Garrett Manufacturing Ltd.
  vol. 5: Pratt & Whitney Aircraft of Canada gas turbine propulsion system retrofit, by Pratt & Whitney Aircraft of Canada Ltd.
  vol. 6: Car structural changes and propulsion system installation, by Bombardier-MLW Ltd.
  vol. 7: Car body improvements and interior modernization, by Bombardier-MLW Ltd.

☒ Conditions hivernales et sécurité des trains de grande vitesse de la ligne Montréal-Québec, par F.L. Peckover. TP 1416F

☒ Effect of winter conditions on the safety of high speed trains on the Montreal-Quebec line, by F.L. Peckover. TP 1416

Evaluation of equipment testing experience, final report, by A. Hugh Paton, Bombardier-MLW Ltd. TP 1127

☒ The feasibility of eddy current track brakes for application to Canadian 125 mph (200 km/h) trains, working paper, by A. Hugh Paton. TP 1130

☒ Inductive coupling for transmission of braking signals in long freight trains, by G.J.M. Aitken, Queen's University, Canadian Institute of Guided Ground Transport. TP 848

☒ Radio-linked train location, identification and control, final report, by Richard J. Pomeroy, Glenayre Electronics Ltd. TP 1216

☒ Settlement of a railway embankment constructed on permafrost peatlands, by EBA Engineering Consultants Ltd.

☒ Stresses and deformations in railway track, by G.P. Raymond, Queen's University, Canadian Institute of Guided Ground Transport. TP 1321

Track/train dynamics - phase III, by Canadian National Research Centre. TP 985

1978

AC motor propulsion systems for multiaxle drives, final report, by University of Toronto, Dept. of Electrical Engineering. TP 1431

☒ Alleviation of detrimental frost heaving of soils by chemical treatment, final report, by R.N. Yong and D.E. Sheeran, McGill University, Geotechnical Research Centre. TP 1408

Analysis of rail track structures (ARTS), user's manual, by G.P. Raymond and D.J. Turcke, Queen's University, Canadian Institute of Guided Ground Transport. TP 1322

Canadian guided ground transport test centre study, final report, by Acres Consulting Services. TP 1734

Comparative evaluation of Transport Canada rail seat: preliminary passenger response, working paper, by Trevor Smith, D. McGrath, J. Smart. TP 1517

☒ Computer aided train dispatch system definition, by Canadian Pacific Consulting Services Ltd. and MPB Technologies Inc. TP 1629

☒ Dynamic measurement of a heavy car wheelset over rails subject to corrugation, by F.B. Blader. TP 1394

☒ Evaluation vibration tests of railway passenger seats, by C.L. Jordan, DND Quality Engineering Test Establishment. TP 2339

☒ Feasibility of special structural designs of locomotives and railcars to improve safety at level crossings, by Dilworth, Secord, Meagher and Associates Ltd. TP 1053

☒ Feasibility study for Vancouver terminal area railcar information system, interim report, by H.A. Simons (International) Ltd. TP 1337

☒ A forecasting method developed for assessing the rail passenger market in the Quebec-Windsor corridor, working paper, by Brian Marshall, TDC. TP 1487

☒ Freight car truck evaluation tests, report LTR-IN-395, by R. Dukkipati and W. Watson, National Research Council.

High speed filming of wheel/rail interaction, by J. Kalousek and R. Gonsalves, Canadian Pacific Ltd. TP 1474

☒ An investigation of the recline mechanism of the Transport Canada commissioned rail passenger seat, by T E S Ltd. TP 2336

Measurement of concrete tie centre bending deflections - Kingston, Albreda & Rivers subdivisions, May 1978, progress report, by J.F. Scott, A. Charenko, CN Rail Research Centre. TP 2628

☒ Performance of frost heave modifying chemical additives at the CN Dorval test site, by D.E. Sheeran and R.N. Yong, McGill University, Geotechnical Research Centre. TP 1814

Pre-test of rail seat evaluation questionnaire, working paper, by Trevor Smith, TDC. TP 1499

Rail passenger seat development: human engineering contributions to the development of a rail passenger seat, by I.Y. Noy and B. Crabtree, Defence and Civil Institute of Environmental Medicine. TP 1784

☒ Rail passenger seat development: Mark I prototype, by Guillon, Smith, Marquart & Associates Ltd. TP 1812

Rail passenger seat development: passenger evaluation, working paper, by Donald McGrath, John Smart, and Trevor Smith. TP 1815

Rail passenger seat strength testing, by T E S Ltd. TP 1648

☒ Stresses and deformations in railway track, by G.P. Raymond, Queen's University, Canadian Institute of Guided Ground Transport. TP 1862

☒ Study of crack initiation in 100-ton coal car truck bolsters, by H. Ghonem, CP Ltd., Department of Research. TP 1681

Summary report, Track/train dynamics - phase 4, by CN Rail Research Centre. TP 1674

☒ Technical feasibility of ride quality monitoring system for rail passenger services, final report, by F.B. Blader. TP 1965

☒ A theoretical analysis of the recline mechanism of the Transport Canada Mk II rail passenger seat, by T E S Ltd. TP 2338

1979

Analyse dynamique d'un petit bogie léger, par Marc Girardin, Bombardier Limitée. TP 2113

☒ Ballast selection and grading, summary report, by G.P. Raymond, C.J. Boon, R.W. Lake, Queen's University, Canadian Institute of Guided Ground Transport. TP 2057

Broken rail detection: an overview of techniques and their effectiveness, by Richard J. Pomeroy, Glenayre Electronics Ltd. TP 2137

Canadian railway electrification study — phase I, summarization of comments, by Maughan Railway Consulting Services Inc. TP 1978

Development of a digital computer program for grade crossing collision analysis, by D.B. Cherchas et al., Queen's University, Canadian Institute of Guided Ground Transport. TP 2496

Effects of CP Rail YARDS car control on rail car handling times at the Vancouver terminal, by Quasar Systems Ltd. TP 2197

Équipement ferroviaire de déneigement — phase 1, par G.J. Ewenson et R.C. Field, Association des chemins de fer du Canada. TP 2180F

Evaluation of premium rail on 8° curves on the B.C. South Line, by P. Gardiner et al., CN Rail Research Centre. TP 2567

An evaluation of the benefits of precast concrete components for road/rail grade separation compared to cast in place construction, working paper, by A. Hugh Paton. TP 2396

Granulométrie et méthode de sélection du ballast, rapport sommaire, par G.P. Raymond, C.J. Boon, R.W. Lake, Université Queen's, Canadian Institute of Guided Ground Transport. TP 2057F

High speed rail passenger demonstration project: discussion of track requirements, by Maughan Railway Consulting Services Inc. TP 1976

High speed rail passenger demonstration project: considerations regarding track for the initial 125 mph operation, by Maughan Railway Consulting Services Inc. TP 1977

Inductively-coupled connectors for signalling and brake control on long freight trains, by G.J.M. Aitken, Queen's University, Canadian Institute of Guided Ground Transport. TP 1966

☒ Location, identification and control system reliability analysis: failure modes and effects analysis, by W. Lee and D. Honkanen, Transport Canada, Telecommunications and Electronics Branch. TP 2063

☒ Locomotive steerable axle truck study, final report, by J.E. Chatfield and D.E. Close, Canadair Ltd. TP 1992

Measurement of concrete tie centre bending deflections — Kingston, Albreda & Rivers Subdivisions, July 1979, by A. Charenko, J.F. Scott, CN Rail Research Centre. TP 2583

Methodology for analyzing the effects of CP Rail YARDS car control on rail car handling times, by Quasar Systems Ltd. TP 2198

Performance and safety standards for rail passenger seat = Résistance et sécurité des fauteuils de trains, by/par TDC/CDT. TP 1598

Predicting requirements for subballast thickness, progress report no. 1, by C.J. Dalton, J.F. Scott, CN Rail Research Centre. TP 2584

☒ Radio-linked train location, identification and control - phase II, final report, by Richard J. Pomeroy, Glenayre Electronics Ltd. TP 2199

Rail passenger seat development: design and prototype manufacture, by Guillon, Smith, Marquart & Associates. TP 1865

Rail passenger seat specification: general application, by TDC and Guillon, Smith, Marquart & Associates. TP 1554

Rail passenger sea specification: LRC application, by TDC and Guillon, Smith, Marquart & Associates. TP 1805

Railway diesel fuel from coal, by Queen's University, Canadian Institute of Guided Ground Transport. TP 2557

☒ Railway snow removal equipment - phase I, by G.J. Ewenson and R.C. Field, Railway Association of Canada. TP 2180

Résistance et sécurité des fauteuils de trains = Performance and safety standards for rail passenger seat, par/by CDT/TDC. TP 1598

☒ Soil stabilization by electro-osmosis: an application to roadbed construction, by CP Rail. TP 2274

Strength testing of the MK II Transport Canada rail passenger seat, by T E S Ltd. TP 2281

Study to define the requirements for railway level crossing protection acceptable for train operations at speeds up to 200 km/h, by Canalog Logistics Inc., Beauchemin, Beaton, Lapointe Inc., and D.W. Shoppert. TP 1996

Summary report track/train dynamics - phase V, by CN Rail. TP 2010

Track data acquisition system: user's manual, by E.R. McIlveen and M.D. Roney, Queen's University, Canadian Institute of Guided Ground Transport. TP 2908

Track/train dynamics - phase III, final report, CP Rail Ltd. TP 2437

Train access system for wheelchair passengers: platform lift design, by Hovey & Associates. TP 2101

Train location, identification, and control prototype system, final report, by BC Railway. TP 1993

☒ Vibration testing of railway seats, by J.K. Robinson, DND, Quality Engineering Test Establishment. TP 2334

YARDS activity reporting and decision system: design phase report, by CP Rail. TP 2007

YARDS activity reporting and decision system: implementation report, by CP Rail. TP 2008

1980

Analysis of rail track structures (ARTS), user's manual, second edition, by G.P. Raymond, D.J. Turcke and D.W. Siu, Queen's University, Canadian Institute of Guided Ground Transport. TP 2603

Application of wayside energy storage system concepts to Canadian railways, by L.M. Cook and L.J. Lawson, Garrett Manufacturing Ltd. TP 2463

Automobile accompanied rail travel to western Canada, the market potential, by T. Smith and B. Myers, TDC. TP 2591

Characteristics of the CN 60A concrete cross tie, by J.F. Scott, CN Rail. TP 2647

Concepts for a system to warn trains of a stalled motor vehicle obstructing the tracks, by James R. Taylor and Jorge M. Rebelo, Canadian Pacific Consulting Services Ltd. TP 2813

Definition and evaluation of a mobile gas dispersion system, by DSMA ATCON Ltd. TP 2606

Effects of 'streaks' on the fracture toughness of chromium-molybdenum rail steel, CP Rail Ltd. TP 2720

The electroslag welding of rail steels, by Queen's University, Canadian Institute of Guided Ground Transport. TP 2598

☒ Étude de compteurs de vitesse pour locomotives, rapport sommaire = Investigation of speedometers for rail locomotives, summary report, par/by L. Garland, D. Ahrens, T E S Ltd. TP 2519

Étude de marché concernant un service de trains auto-couchettes vers l'ouest canadien, par T. Smith et B. Myers, CDT. TP 2591F

☒ Experimental and AAR wheel profile measurements on a CP unit coal train, by G. Izbinsky, W. Pak, CP Ltd. TP 2728

Fuel supply for diesel locomotives, by M.J. Lovett, Hycarb Engineering Ltd. TP 2709

Fuel supply for diesel locomotives, summary report, by M.J. Lovett, Hycarb Engineering Ltd. TP 2767

Impact loading measurements on CN 60A concrete ties, by J.F. Scott, CN Rail. TP 2649

Les installations d'essai à climat contrôlé vues par l'industrie ferroviaire, par Canalog Logistics Ltée. TP 2691F

An investigation of speedometers for rail locomotives, final report, by L. Garland, D. Ahrens, T E S Ltd. TP 2518

☒ An investigation of speedometers for rail locomotives, summary report = Étude de compteurs de vitesse pour locomotives, rapport sommaire, by/par L. Garland, D. Ahrens, T E S Ltd. TP 2519

Locomotive truck improvement study — phase II, steerable axles and resilient motor suspension, Canadair Ltd. TP 2661

Manual for three-dimensional sub-surface contact stress analysis program for wheel/rail interaction, by W. Pak, CP Ltd. TP 2792

Mise au point d'un siège pour train de voyageurs, rapport sommaire, par T.K. Gillies. TP 2490F

Planning of a research programme for the air brake system for freight trains, by R.M.H. Cheng, Concordia University, Fluid Control Centre. TP 2462

☒ Prediction of long term track subgrade settlement due to cyclic wheel loading, by D.E. Sheeran, H.M. Elmamlouk and E.A. Fattah, CN Rail. TP 2648

Rail passenger seat development, summary report, by T.K. Gillies. TP 2490

☒ Rail passenger seat development: revenue service evaluation, by T. Secord, VIA Rail, and W. Rowan, TDC. TP 2118

Railway perspective of controlled-climate testing, by Canalog Logistics Ltd. TP 2691

Railway perspective of controlled climate testing - supplementary information, by H.L. Betts and H.C. Weaver, Canalog Logistics Ltd. TP 2691 Supp.

Study of an AC rotary induction motor-powered steerable railway truck, by R.E. Smith, H.J. Dorosh, D.P. Chadwick, Urban Transportation Development Corporation. TP 2464

Testing and evaluation of the Explosafe system as a method of controlling boiling liquid expanding vapour explosion (BLEVE), by R.D. Appleyard, Vulcan Industrial Packaging Ltd. TP 2740

Track structures test facility, progress report no. 4: Concrete tie center bending moments with track settlement and frost heave, by J.F. Scott and A. Charenko, CN Rail. TP 2650

Track/train dynamics — phase VI, final report, by R.P. Rennie, CN Rail Research Centre. TP 2533

YARDS activity reporting and decision system: post project evaluation report, by CP Rail. TP 2547

1981

1980 laboratory research on concrete ties, by J.F. Scott, CN Rail Research Centre. TP 3585

☒ Advanced train control project for Canadian railways — phase 1, study of advanced train control technologies, final report, by T.E. Munford. TP 3243

Application of radio-linked signaling to the Montreal-Quebec City rail passenger route, by J.R. Taylor, F.G.R. Warren and R.J. Pomeroy, Canadian Pacific Consulting Services Ltd. TP 3019E

Canadian diesel locomotive fuel in the eighties, by R.G. Maughan, Railway Association of Canada. TP 3140

Comparison of Wyle and CP angle-of-attack data, by H. Ghonem, CP Ltd. TP 3032

Concept of a profilometer for rail wear determination, by G. Izbinsky and G. Warshaw, CP Ltd. TP 3503

Curving performance analysis of four freight car trucks, by R. Young and P.P. Marcotte, Dynamic Sciences Ltd. TP 3211

Curving performance of SD-40 locomotive trucks, by W. Pak, CP Ltd. TP 3050

Diesel electric locomotive noise study, by D. Satsangi, Bombardier Inc. TP 2986

☒ Guided ground transport research problems — part 1, conventional rail concepts, by Queen's University, Canadian Institute of Guided Ground Transport. TP 3451

High speed trains in France: Paris-sud-est, by Joseph Jones, Queen's University, Canadian Institute of Guided Ground Transport. TP 3524

Locomotive cab information display, by R.J. Pomeroy and R. Wortman, Glenayre Electronics Ltd. TP 3630E

Measurement of concrete tie center bending deflections, Albreda and Rivers subdivisions — September 1980, by A. Charenko and J.F. Scott, CN Rail Research Centre. TP 3346

Praticabilité technique et économique d'un système de trains autos-couchettes au Canada = Technical and economic feasibility of a Canadian auto train, par/by J.M. Rebelo, Société d'études et de consultation du Canadien Pacifique/Canadian Pacific Consulting Services Ltd. TP 3119

Predicting requirements for subballast thickness, progress report no. 2, by C.J. Dalton and J.F. Scott, CN Rail Research Centre. TP 2987

Quebec Cartier Mining Company engineering definition study for an electrification demonstration, field survey report, by L.D. Tufts, J.R. Appleyard and J. Stevenson, Canadian Pacific Consulting Services Ltd. TP 2961

☒ Railroad Dynamics Incorporated (RDI) truck evaluation test, by R. Gonsalves, W. Pak and G. Izbinsky, CP Ltd. TP 2970

Safety relief valve literature search and synthesis, by Dr. Allan W. King, Queen's University, Canadian Institute of Guided Ground Transport. TP 3293E

The Stirling engine for railway locomotive application, by G. Walker, Whitegailes Engineering Ltd. TP 2930

The Stirling engine for railway locomotive application, summary report, by G. Walker, Whitegailes Engineering Ltd. TP 3242

☒ Technical and economic feasibility of a Canadian auto train, by J.M. Rebelo, Canadian Pacific Consulting Services Ltd. TP 3041

Technical and economic feasibility of a Canadian auto train = Praticabilité technique et économique d'un système de trains autos-couchettes au Canada, by/par J.M. Rebelo, Canadian Pacific Consulting Services Ltd./Société d'études et de consultation du Canadien Pacifique. TP 3119

Theoretical curving performance of four freight car trucks, by W. Pak and G. Rosval, CN Rail. TP 3449

Track/train dynamics — phase IV, final report, by CP Rail. TP 3120

☒ Track/train dynamics - phase VII, final report, by R.P. Rennie, CN Rail. TP 2948

1982

A.C. traction motors for locomotives, by H. Dorosh, Brown Boveri Canada Ltd. TP 3388E

Concept definition of wayside energy storage systems (WESS) for railway electrification, final report, by A.B. Turner, F.W. Eyre and D. Murphy, SNC Inc. TP 3622E

Concept definition of wayside energy storage systems (WESS) for railway electrification, summary report, by A.B. Turner, F.W. Eyre and D. Murphy, SNC Inc. TP 3610E

Définition du concept de systèmes de stockage d'énergie en bordure des voies (SSE) pour l'électrification ferroviaire, rapport sommaire, par A.B. Turner, F.W. Eyre et D. Murphy, SNC Inc. TP 3610F

Electrification study for British Columbia Railway Tumbler Ridge branch line, by M. Sugimoto and D.R. Stirling, Canadian Pacific Consulting Services Ltd. TP 3619E

Engineering study for an electrification demonstration project with the Cartier Railway Company, final report, by L.C. Tait, J.R. Taylor and D.F. Haney, Canadian Pacific Consulting Services Ltd. TP 3525E

Engineering study for an electrification demonstration project with the Cartier Railway Company, summary report, by L.C. Tait, J.R. Taylor and D.F. Haney, Canadian Pacific Consulting Services Ltd. TP 3611E

Étude technique relative au projet pilote d'électrification d'un tronçon de voie ferrée appartenant à la compagnie de Chemin de fer Cartier, rapport sommaire, par L.C. Tait, J.R. Taylor et D.F. Haney, Société d'études et de consultation du Canadien Pacifique. TP 3611F

Precast prestressed concrete for railway/highway grade separation structures, by R.G. Maughan, Maughan Railway Consulting Services Inc. TP 3397

Track structures test facility, progress report no. 5: measurement of track modulus, by A. Charenko and J.F. Scott, CN Rail Research Centre. TP 3586

Track/train dynamics — phase VIII, final report, by R.P. Rennie, CN Rail. TP 3584

Surface Technology

1971 - 1973

☒ The age of leisure and Canadian highways (Canadian highway system study, vol. 4), by TDA.

☒ Airport access in Canada, by V. Setty Pendakur, TDA.

Blue Arrow, 9 volumes, by City of Calgary, Transportation Department:
  vol. 1-2: Systems design and evaluation.
  vol. 3: Assessment of radio control system.
  vol. 4: A merchandising and marketing research project.
  vol. 5: Reduced fare experiment.
  vol. 6: Dial-a-ride transit demonstration project.
  vol. 7: Assessment of contra-flow bus lanes.
  vol. 8: Financial report.
  vol. 9: Comprehensive review.

☒ A comparative study of Canadian provincial highway legislation, by Ling Suen and William Dere, TDA.

☒ Construction of a full-size experimental aerotrain guideway, by M. Schwirtz et al., TDA.

☒ Dial-a-bus implementation: theory and practice in Canada, by Ling Suen and Howard Johnson, TDA.

☒ Ecology and ground transportation on the Canadian tundra, by J.D.H. Lambert, TDA.

☒ The environmental impact of highways in the provincial boreal forest region of Canada, by Hedlin, Menzies and Associates Ltd.

- ☒ Experimental studies on solids pipelining of Canadian commodities for the Canadian Transport Commission and the Transportation Development Agency, by Saskatchewan Research Council.
- ☒ Federal interest in highways: an historical perspective (Canadian highway system study, vol. 1), by V. Setty Pendakur and D. Leslie Burke.
- ☒ Geographical distribution of for-hire trucking firms in the Montreal metropolitan area, working paper, by Michel Caron, TDA.
- ☒ Guided ground transportation study: a review and bibliography of advanced systems - 2 volumes, by Canadair Ltd.
- ☒ High rise living, by V. Setty Pendakur, TDA.
- ☒ Highway traffic volume forecasts for the Atlantic provinces, 1970-1982, by Searle, Wilbee, Rowland Consultants Ltd.
- ☒ Inventory of advanced urban and regional surface transportation systems, by Daniel G. Hargreaves, TDA.
- ☒ National market for urban transit vehicles, summary report, by Kates, Peat, Marwick & Co.
- ☒ New technology and Canadian highways: a preliminary assessment, 1972-1982 (Canadian highway system study, vol. 3), by V. Setty Pendakur and Neal A. Irwin.
- ☒ Personal transportation of goods in Montreal, study report, by R.K. Lansdell, TDA.
- ☒ Population projections (Canadian highway system study, vol. 2), by V. Setty Pendakur and William J. Cowie.
- ☒ The prospect for urban mobility, by C. Beaumont Lewis, TDA.
- ☒ Regenerative chopper traction equipment on six TTC subway cars, by Toronto Transit Commission.
- ☒ Regina telebus study - 6 volumes, by W.G. Atkinson, R.P. Couturier and L. Suen, TDC:
    - vol. 1: Summary report of the Regina telebus demonstration.
    - vol. 2: Feasibility study and illustrated summary report.
    - vol. 3: Transportation data report.
    - vol. 4: Operations report.
    - vol. 5: Financial report.
    - vol. 6: The impact of telebus.
- ☒ Répartition géographique des entreprises de camionnage dans la région métropolitaine de Montréal, document de travail, par Michel Caron, CDT.
- ☒ Research directions in urban transportation, by C. Beaumont Lewis, TDA.
- ☒ Some environmental considerations in northern road planning, construction and maintenance, by Ian McTaggart-Cowan.
- ☒ Study of magnetic levitation and linear synchronous motor propulsion, by Queen's University, Canadian Institute of Guided Ground Transport.
- ☒ TDA-RCA capsule pipeline project: Capsule pipeline system analysis, edited by Erik J. Jensen, Research Council of Alberta.
- ☒ Transportation service measures, by Kates, Peat, Marwick & Co.
- ☒ The urban commodity flow data collection project, final report, by TDA and University of Calgary Institute for Transportation Studies.

☒ Urban goods movement in Canadian cities, phase I (Urban goods movement report series, vol. 2), by N.D. Lea & Associates Ltd. TP 1781

☒ Vehicle-free zones in Canadian cities, by K. Knechtel, Ministry of Transport, et al.

1974 - 1976

☒ Advanced technology study: intermediate capacity transit - 2 volumes, by TDA.

☒ Alternative roles for the taxi in urban transport, by Denis Couture, TDA. TP 1198

Amélioration des services de déneigement dans les villes canadiennes, par le Bureau des Conseillers en Gestion et CDT.

☒ Analysis of superconducting magnetic levitation and linear synchronous motor propulsion for high speed ground transportation, by Queen's University, Canadian Institute of Guided Ground Transport.

An assessment of urban transportation technology research and development, by Lloyd A. McCoomb, TDA.

☒ Automated driver and vehicle allocation for public transit: a report on RUCUS, by the Systems Group. TP 522

Automated vehicle monitoring trial on a Vancouver main bus transit route, by TDA. TP 236

☒ Bus lane operating strategies in downtown areas, final report, by De Leuw Cather Canada Ltd. TP 450

☒ Bus lane operating strategies in downtown areas, executive summary = Stratégies d'opération des voies d'autobus dans un quartier commercial, exposé administratif, by/par De Leuw Cather Canada Ltd. TP 449

☒ Bathurst pooling case study, by ADI Limited. TP 605

☒ Bus priority at traffic signals, by D. Whitehead and D.M. Beere.

☒ Bus priority systems: report of the Working Party on Bus Priority Systems, report no. 45, a project of the pilot study on urban transportation, by North Atlantic Treaty Organization, Committee on the Challenges of Modern Society.

☒ Computer animated simulation of taxi dispatching strategies, working paper, by TDA. TP 294

A concept definition study for city center circulation systems, by N.D. Lea and Associates Ltd. TP 290

☒ Data acquisition system, design manual, by E.R. Corneil, Queen's University, Canadian Institute of Guided Ground Transport.

Dial-a-bus dossier - 2 volumes, par CDT.

Dial-a-bus manual - 2 volumes, by TDA.

☒ EMME: coding the transit network to permit interface with the road network for the purpose of bi-modal assignment, by Claude Achim and Robert Chapleau, Université de Montréal, Centre de recherche sur les transports.

☒ Enquête et inventaire des techniques informatisées de planification du transport urbain, dernier rapport, par Université de Montréal, Centre de recherche sur les transports. TP 1206F

E-shaped electromagnetic suspension magnet: calculated and experimental static and heave force characteristics, by S.D.T. Robertson et al., University of Toronto Institute for Aerospace Studies. TP 252

Essai de contrôle automatique du mouvement des véhicules sur une ligne principale d'autobus à Vancouver, par CDT. TP 236F

☒ Étude des droits de passage existants pour applications de systèmes de transport à capacité intermédiaire dans les villes du Canada, par De Leuw Cather Canada Ltd.:
    Ville de Montréal. TP 261F
    Ottawa-Hull. TP 264F

☒ Étude des mesures visant à encourager la construction et l'achat de voitures à faible consommation de carburant, vol. I, par N.D. Lea & Associates Ltd. TP 591F

Évaluation de l'impact des mesures visant à encourager la production d'automobiles à faible consommation de carburant chez les constructeurs nord-américains, vol. II, par N.D. Lea & Associates Ltd. TP 592F

☒ Évaluation des aérobacs, par Peter L. Eggleton et J. Laframboise, CDT.

An evaluation of carpool matching systems, by Douglas M. Peterson, University of Toronto. TP 292

☒ Field evaluation of towed air cushion rafts, by Peter L. Eggleton and J. Laframboise, TDA.

☒ Future urban travel patterns, by A. Frayne, TDA.

Highway systems in Canada, by TDA. TP 381

☒ Improved operations of urban transportation systems - 3 volumes, by Corporation of Metropolitan Toronto, Roads and Traffic Department:
    vol. 1: Traffic signal control strategies: a state-of-the-art.
    vol. 2: The evaluation of off-line area traffic control strategies.
    vol. 3: The development and evaluation of a real-time computerized traffic control strategy.

Improving snow clearing effectiveness in Canadian municipalities, by TDC and the Bureau of Management Consulting Services.

☒ Legal and institutional issues in implementing public or privately sponsored carpooling programs in Canada, by Sandra Glasbeek, University of Toronto. TP 258

☒ Les méthodes de limitation de la circulation automobile et de conservation de l'énergie dans les centres urbains au Canada: analyse légale et institutionnelle, rapport préliminaire, par D. Couture, Transports Canada, Direction de la recherche sur les transports urbains. TP 1253

☒ Mississauga Transit automatic bus passenger information project: plan for a demonstration of a manual system, by Josef Kates Associates Inc.

☒ Opérations du Voyageur ACV dans le climat arctique, par C. Preston, CDT.

☒ Ottawa-Carleton bus surveillance and control related to the computerized signal system, final report, by JHK & Associates.

☒ Overview of paratransit research: a working paper examining legal, institutional and financial constraints, by Peter Strobach, TDA.

Para-transit dispatch systems, summary report, by Josef Kates Associates Inc.

☒ Preliminary design and cost estimates for eastern Arctic pipelines, by Techman Ltd.

☒ La préparation de la liste d'assignation des chauffeurs d'autobus d'une compagnie de transport en commun, par Réjean Lessard, Université de Montréal, Centre de recherche sur les transports.

☒ The problem of assigning drivers to bus routes in an urban transit system, by J.Y. Blais, Université de Montréal, Centre de recherche sur les transports.

☒ Profile of urban goods flow in Calgary, Alberta, summer 1972, by Ling Suen, TDA.

☒ A profile of urban goods in Calgary (Urban goods movement report series, vol. 3), by N.D. Lea and Associates Ltd. TP 1074

☒ Progress report on research related to tracked air cushion vehicle suspension dynamics, by P.A. Sullivan, University of Toronto Institute for Aerospace Studies.

☒ A proposal for a carpool program for federal civil service employees in the National Capital Region, by Lloyd A. McCoomb, TDA.

RUCUS implementation for city of Kitchener, final report, by Canada Systems Group. TP 520

☒ Reports containing transportation planning data for Canadian cities: a bibliography, by William F. Johnson and Hetty St. Hill, TDA.

A shared ride taxi feasibility study for the Battlefords, Saskatchewan, working paper, by N.D. Lea and Associates Ltd. and L.B. Grimble and Associates Ltd. TP 852

Stratégies d'opération des voies d'autobus dans un quartier commercial, exposé administratif = Bus lane operating strategies in downtown areas, executive summary, par/by De Leuw Cather Canada Ltd. TP 449

☒ A study of bus operational improvements, by Sam Yagar. TP 521

☒ A study of carpooling in an urban transportation environment, phase I - preliminary overview, by the Bureau of Management Consulting Services. TP 288

☒ A study of existing rights-of-way for intermediate capacity transit applications in Canadian cities - 11 volumes, by De Leuw Cather Canada Ltd.:
    Montreal. TP 261, TP 261F
    Toronto. TP 262
    Winnipeg. TP 263
    Ottawa-Hull. TP 264, TP 264F
    Quebec City. TP 265
    Edmonton. TP 266
    Calgary. TP 267
    Windsor. TP 268
    Hamilton. TP 269
    Halifax. TP 270
    London. TP 271

☒ A study of measures to encourage the adoption of more energy efficient automobiles - 2 volumes, working papers, by N.D. Lea and Associates Ltd. TP 591, 592

☒ Superconducting linear synchronous motor propulsion and magnetic levitation for high speed guided ground transportation, by Canadian Maglev Group.

☒ Survey and inventory of computer-based urban transportation planning techniques, final preliminary report, by Université de Montréal, Centre de recherche sur les transports. TP 1206

☒ Systèmes de régulation des transports semi-collectifs, rapport sommaire, par Josef Kates Associates Inc.

☒ Les systèmes routiers du Canada, par CDT. TP 381F

☒ TDA-RCA capsule pipeline project, phase II report, edited by Erik J. Jensen, Research Council of Alberta.

☒ Theoretical benefits of staggered work hours, by Sam Yagar. TP 1237

☒ A traffic equilibrium model of travel by car and public transit modes, by Michael Florian, Université de Montréal, Centre de recherche sur les transports.

☒ Transit route development and evaluation techniques: a survey of the state-of-the-art, by Université de Montréal, Centre de recherche sur les transports. TP 451

☒ Urban structure and transportation inter-relationships research program, by Morris Trevithick Associates Ltd.

Urban transportation data base: population and household characteristics, by Hetty St. Hill, TDA. TP 651

☒ Value of time in urban travel: bibliography, by William F. Johnson and Hetty St. Hill, TDA.

☒ Vehicle location system: pilot project: report on computer system facilities, by G.M. Yendole, British Columbia Hydro and Power Authority.

☒ Winnipeg Southwest transit corridor study, report on phase I: feasibility, by De Leuw, Dillon. TP 613

1977

☒ Assessment of Winnipeg Transit Department vehicle monitoring system, by Petrie Telecommunications Limited. TP 1236

☒ BUSCHED evaluation project for Sudbury Transit, summary report = Projet d'évaluation du modèle BUSCHED pour Sudbury Transit, rapport sommaire, by/par Transpotech. TP 1953

Bus and truck driver training simulator study, by R.F. Stapells and Associates Ltd. TP 1279

Charlottetown parking and paratransit feasibility study, by Development Planning Associates Limited. TP 854

☒ Demand response transit: proposed step-to-step operations for Ottawa: vehicle scheduling algorithms and system performance evaluation, working paper, by Mark Oksenhendler. TP 695

☒ Development of carpool marketing model using Vancouver commuter club data, working paper, by the Bureau of Management Consulting Services. TP 1268

☒ Easy Rider: the Mississauga transit demonstration of the automatic bus passenger information concept, by Josef Kates Associates Inc.

☒ The effects of federal government parking policy on modal choice among federal government employees in Ottawa, working paper, by David W. Gillen. TP 752

Electrodynamic suspension and linear synchronous motor propulsion for high speed ground transportation — phase III, contract report, April 1976 - September 1977, by Canadian Maglev Group. TP 1443

Étude sur l'adoption d'un simulateur pour l'entrainement des chauffeurs d'autobus et de camions, par R.F Stapells and Associates Ltd. TP 1279F.

Étude théorique et comparaison expérimentale de moteurs linéaires à induction compensée, par Farid Dawalibi, Normand Rivest et Dinkar Mukhedkar. TP 847

☒ Evaluating the potential of a radio-linked signaling system for urban transit application - 2 volumes, by Urban Transportation Development Corporation Ltd.

Executive summary of high speed Maglev guided ground transportation system conceptual design study, by W.F. Hayes, National Research Council. TP 1309

☒ Extraprovincial motor carrier licensing reciprocity study, by R.K. House & Associates. TP 1336

☒ Fare policies, fare structures and fare collection methods, by Precursor Limited. TP 909

☒ The feasibility of electric vehicles in Canada, by N.D. Lea and Associates Ltd. TP 1278

Feasibility review of automated typesetting for public timetables for Calgary transit, by DeLeuw Cather. TP 1307

Final report on random vehicle monitoring tests, by City of Winnipeg Transit System. TP 1235

High speed electrodynamic Maglev guided ground transportation system conceptual design study, by W.F. Hayes, National Research Council. TP 1308

☒ Integrated urban transportation control systems - 2 volumes, working papers, by IBI Group and Peat, Marwick and Partners. TP 1003

☒ An investigation of the roll stiffness characteristics of three flexible skirted cushion systems, by P.A. Sullivan, M.J. Hinchey and R.G. Delaney, University of Toronto Institute for Aerospace Studies. TP 698

☒ Labour and urban transit operations: profile and prospects, by Sage Management Consultants. TP 1430

☒ Labour force survey journey-to-work supplement, Nov. 1976: preliminary analysis, by H. Côté and L.A. McCoomb, TDA.

☒ La main-d'oeuvre et les transports urbains: profil et perspectives, document de travail, par Sage Management Consultants. TP 1430F

Market evaluation and development program definition for AC motor propulsion system for transit applications - 2 volumes, by SPAR Aerospace Products. TP 1107

Normalisation des services - 6 volumes, par la Commission de transport de la Communauté urbaine de Québec:
    Phase I, Développement des normes de service. TP 1075
    Enquête sur les critères de services existants. TP 1076
    Normes de service. TP 1436
    Phase II, Analyse de l'impact des normes de service sur le réseau de la CTCUQ. TP 1437
    Résumé/Summary. TP 1438
☒   Annexe technique, les temps de déplacement sur le territoire de la CTCUQ. TP 1439

☒ The Ottawa bus-pass system: an examination of effects, by the Bureau of Management Consulting Services. TP 1064

☒ Project turn down traffic volume - 6 volumes, by Vancouver, B.C., Engineering Department:
    technical report no. 1: Project design and evaluation plan. TP 727
    technical report no. 2: Evaluation of pilot project results. TP 728
    technical report no. 3: Marketing. TP 729
    technical report no. 4: The car pool demonstration. TP 730
    technical report no. 5: The variable working times demonstration. TP 731
    technical report no. 6: Overall project review. TP 732

☒ Projet d'évaluation du modèle BUSCHED pour Sudbury Transit, rapport sommaire = BUSCHED evaluation project for Sudbury Transit, summary report, par/by Transpotech. TP 1953

☒ Research on stability of air cushion systems, by M.J. Hinchey et al., University of Toronto Institute for Aerospace Studies. TP 1469

A shared-ride taxi feasibility and design study in Bathurst, New Brunswick, by N.D. Lea and Associates Ltd. TP 794

A study into the development of flywheel energy storage technology for Canadian transportation applications, by Urban Transportation Development Corporation. TP 904

☒ A study of carpooling in an urban transportation environment: phase 2, methodology and data base specification, by the Bureau of Management Consulting Services. TP 289

☒ Study of off street urban trucking endpoint facilities, working paper (Urban goods movement report series, vol. 8), by J. Paynter. TP 793

Le système des cartes d'autobus à Ottawa: étude des répercussions, par le Bureau des conseillers en gestion. TP 1064F

☒ A theoretical and experimental investigation of a hinged lip tracked air cushion vehicle suspension system, by J.G. Parravano and P.A. Sullivan, University of Toronto Institute for Aerospace Studies. TP 930

☒ Transit mapping practices in Canada, by Precursor Ltd. TP 1315

☒ Transportation and the flywheel, by D.S. Grant, Queen's University, Canadian Institute of Guided Ground Transport. TP 1105

Transportation policy and transit improvement study for the city of Regina - 4 volumes, by N.D. Lea and Associates Ltd. TP 853:

- ☒ vol. 1: Existing transit system December 1976 with immediate improvements.
- vol. 2: 10 year development program.
- vol. 3: 25 year development program.
- vol. 4: Summary.

☒ Transportation pooling: a review of eastern Canadian pooling systems, working paper, by Transport Canada, Urban Transportation Research Branch. TP 858

☒ Urban railway inventory, working paper - 13 volumes, by Canadian Pacific Consulting Services Ltd.:

- vol. 1: Calgary. TP 753
- vol. 2: Edmonton. TP 754
- vol. 3: Halifax. TP 755
- vol. 4: Hamilton. TP 756
- vol. 5: Kitchener-Waterloo. TP 757
- vol. 6: London. TP 758
- vol. 7: Montreal. TP 759
- vol. 8: Ottawa-Hull. TP 760
- vol. 9: Quebec. TP 761
- vol. 10: Regina. TP 762
- vol. 11: Windsor. TP 763
- vol. 12: Winnipeg. TP 764
- vol. 13: Vancouver. TP 765

☒ Winnipeg southwest transit corridor study: report on Phase II: recommended system, by De Leuw, Dillon. TP 1234

1978

Un algorithme d'affectation des chauffeurs d'autobus: un test à la CTCUM (projet HASTUS) = Algorithm for the assignment of bus drivers: a test carried out at the MUCTC (Project HASTUS), par/by Jean-Marc Rousseau et al., Université de Montréal, Centre de recherche sur les transports. TP 1644

☒ An analysis of rider behaviour conducted during the initial period of operation of the Edmonton LRRT service, by Ben Barkow and F.D. Bell, Behavioural Team. TP 1748

☒ Aperçu des activités de transport semi-collectif au Canada, document de travail, par Agnes Lehuen et Ling Suen, Transports Canada, Direction de la recherche sur le transport urbain. TP 1464F

☒ An assessment of the potential for improving urban transit marketing in Canada, working paper, by George S. Day and Associates Ltd. TP 1591

Canadian urban transport research information structure and data base, Phase I, executive summary and technical appendix, N.D. Lea and Associates Ltd. TP 1819

The Caspar ACV research project, report no. 6: the use of a non-dimensional quantitative of lift airflow applicable to any ACV, by H.S. Fowler, National Research Council. TP 1518

The Caspar ACV research project, report no. 7: the development of a system and equipment for terrain porosity measurement, by H.S. Fowler, National Research Council. TP 1519

☒ City centre pedestrian systems: a state-of-the-art review, working paper, by Hannah Shostack, Transport Canada, Urban Transportation Research Branch. TP 1199

☒ Collecte et analyse des données sur le transport en commun: section 1, montées et descentes; section 2, les modèles d'arrivée des usagers = Collection and analysis of data on public transit: section 1, bus boarding and alighting operations; section 2, arrival pattern of the users, par/by École polytechnique de l'Université de Montréal, Centre de développement technologique. TP 1856

☒ Comparison of three arterial traffic control strategies through field measurements, by Gabriel Heti et al., Ministry of Transportation and Communications (Ontario). TP 1871

Concept definition study of an intermediate capacity transit system, summary reports - 3 volumes, by Bombardier Ltée:
  vol. 1: System standards and feasible technical solutions. TP 1391
  vol. 2: Technology selection for subsystems. TP 1392
  vol. 3: System integration and cost analysis. TP 1393

Conservation de l'énergie dans le transport urbain des marchandises (Urban goods movement report series, vol. 6), document de travail, par J.F. Morrall et al., University of Calgary, Dept. of Civil Engineering. TP 1664F

☒ Les contributions municipales au transport en commun, par Gabriel Fortin. TP 1831F

☒ Cost sharing for inter-municipal transit, summary report, by Gabriel Fortin. TP 1832

The costs of urban travel in Canada = Les coûts des déplacements urbains au Canada, by/par A. Frayne, F. Kagan, Transport Canada, Urban Transportation Research Branch/Transports Canada, Direction de la recherche sur les transports urbains. TP 1594

The effects of the imposition of parking charges on urban travel in Ottawa, summary report = Incidences de l'imposition des frais de stationnement sur le transport urbain à Ottawa, rapport sommaire, by/par De Leuw Cather Canada Ltd. TP 291

☒ Energy effects of carpooling: the Vancouver case, working paper, by the Bureau of Management Consulting Services. TP 1788

Étude conceptuelle d'un système de transport urbain à capacité intermédiaire, rapport final - 10 volumes, par Bombardier Ltée:
vol. 1: Normes - détermination des spécifications fonctionnelles. TP 1381
vol. 2: Exploitation - Études des modes d'exploitation. TP 1382
vol. 3: Véhicule. TP 1383, 1383 Annexes
vol. 4: Traction - motorisation et équipements électriques. TP 1384
vol. 5: Automatisme. TP 1385, 1385 Annexes
vol. 6: Stations - fonctions et configurations des stations. TP 1386
vol. 7: Infrastructure. TP 1387
vol. 8: Insertion - insertion sur emprises ferroviaires et routières. TP 1388
vol. 9: Déneigement. TP 1389
vol. 10: Analyse économique et financière. TP 1390

Étude conceptuelle d'un système de transport urbain à capacité intermédiaire (STCI), rapports sommaires - 3 volumes, par Bombardier Ltée:
vol. 1: Spécifications fonctionnelles du système et solutions envisageables. TP 1391F
vol. 2: Choix technologiques pour les sous-systèmes. TP 1392F
vol. 3: Intégration technique et analyse économique. TP 1393F

Evaluation of air cushion assist: an evaluation of air cushion assisted vehicles for on-road freight transportation in the provinces of Saskatchewan and Alberta, by D. Eyre, Transportation Agency of Saskatchewan. TP 1485

☒ Évaluations des possibilités d'améliorer le marketing du transport urbain au Canada, document de travail, par George S. Day and Associates Ltd. TP 1591F

Incidences de l'imposition des frais de stationnement sur le transport urbain à Ottawa = The effects of the imposition of increased parking charges on urban travel in Ottawa, rapport sommaire/summary report, par/by Transports Canada/Transport Canada. TP 291

Mississauga Transit Easy Rider Service: demonstration of Automated Bus Passenger Information system (ABPI), progress reports no. 1-4, by Transport Canada, Urban Transportation Research Branch. TP 1646

La Mississauga Transit Easy Rider Service: la démonstration du système de renseignements informatisé au service des usagers d'autobus (ABPI), rapports sur l'état actuel 3-4, par Transports Canada, Direction de la recherche sur les transports urbains. TP 1646F

☒ Montreal/Quebec City survey of Voyageur bus travellers, working paper, by TDC. TP 1486

☒ Myths and realities of urban pickup and delivery operations, (Urban goods movement report series, vol. 4), by Clayton, Sparks and Associates Ltd. TP 1741

☒ Optimum bus stop spacing, final report, by Allen S. Berg and Ben Barkow, Transportation Systems and Software, Behavioural Team. TP 1843

☒ An overview of paratransit activities in Canada, working paper, by Agnes Lehuen and Ling Suen, Transport Canada, Urban Transportation Research Branch. TP 1464

☒ Potential energy conservation in urban commodity flow (Urban goods movement report series, vol. 6), by J.E. Morrall et al., University of Calgary, Dept. of Civil Engineering. TP 1664

☒ Research on air cushion stability, by University of Toronto Institute for Aerospace Studies. TP 1760

☒ Strategies for future development of the Whitehorse mini-bus system, by Joanne Linzey. TP 1864

A study of the effect of computer aided dispatching on the Intercab Dispatch System, working paper, by International Aeradio Ltd. TP 1523

☒ Transit service options for small cities, by N.D. Lea and Associates Ltd. TP 1608

☒ Transportation services in low density areas: innovational systems, by Agnes Lehuen, Transport Canada, Urban Transportation Research Branch. TP 1466

☒ Transports en commun dans les petites villes: les choix, par N.D. Lea and Associates Ltd. TP 1608F

☒ The trucking industry in Canada, 1980-1990: road freight technology, by Huot & Associates. TP 1305

1979-1980

Alternatives to air: a feasible concept for the Toronto-Ottawa-Montreal corridor, final report - 3 volumes, by R.W. Lake, C.J. Boon, G.W. English et al., Queen's University, Canadian Institute of Guided Ground Transport. TP 2667

Alternatives à l'aviation: un concept praticable pour le corridor Toronto-Ottawa-Montréal, rapport sommaire, par R.W. Lake, C.J. Boon, G.W. English et al., Queen's University, Canadian Institute of Guided Ground Transport. TP 2827

Alternatives to air: a feasible concept for the Toronto-Ottawa-Montreal corridor, summary report, by R.W. Lake, C.J. Boon, G.W. English et al., Queen's University, Canadian Institute of Guided Ground Transport. TP 2827

☒ Analyse d'un système aéroportuaire de transport sur demande (DRT), par Transports Canada, Direction des études stratégiques et Direction de la recherche sur les transports urbains. TP 953F

Analysis of results of intercity bus passenger surveys on Montreal-Ottawa, Montreal-Toronto and Montreal-Quebec routes, by James P. Cluchey and Barry B. Myers, TDC. TP 2434

Annotated bibliography on demand responsive scheduling systems, by University of Toronto, Centre for Urban and Community Studies. TP 1898

☒ Calgary Transit dial-a-bus reservation processing system, by Alberta Department of Transportation. TP 1714

☒ Canadian transit handbook, edited by Richard M. Soberman and Heather A. Hazard, University of Toronto-York University Joint Program in Transportation. TP 2741

☒ Canadian urban modelling: a review of innovative urban modelling techniques, by IBI Group. TP 2011

☒ Changeable message sign - Queen Elizabeth Way, Mississauga, by Transport Canada, Urban Transportation Research Branch. TP 2507

Comparative experimental evaluation of the performance of a SLIM with a solid-steel reaction rail and with an aluminum-capped reaction rail, by A.R. Eastham, G.E. Dawson, D.M. Pringle et al., Queen's University, Canadian Institute of Guided Ground Transport. TP 2909

☒ Computerized dispatching for shared-ride taxi operations in Canada, by L. Suen and A. Ebrahim, Transport Canada, Urban Transportation Research Branch. TP 2354

☒ Consolidated building receiver demonstration (Urban goods movement report series, vol. 7), by Sushill K. Bhattacharyya, TEE Consulting Inc. TP 1833

Cross sectional analysis of Canadian urban transit systems performance in 1976, by Presage Research Ltd. TP 2203

☒ Demand responsive dispatching systems: a study of task complexity, by G. Haines, University of Toronto. TP 908

Démonstration à la Mississauga Transit du système de renseignements informatisé au service des usagers d'autobus: Easy Rider, par Group IBI et Josef Kates Associates Inc. TP 2048F

Design interactif de systèmes de signalisation à l'aide d'ordinateur hybride, par Michael P. Polis et Alain Janelle, École polytechnique de l'Université de Montréal, Centre de développement technique. TP 2460

Development and testing of an electronic route sign for transit vehicles, by B.C. Hydro & Power Authority. TP 2052

Differential icing on bridge decks, final report, by R.S. Jagla and I.K. Upjohn, Fenco Consultants Ltd. TP 2845

Differential icing on bridge decks = Glaciation différentielle des tabliers de ponts, summary report/rapport sommaire, by/par R.S. Jagla and/et I.K. Upjohn, Fenco Consultants Ltd. TP 2844

☒ Direction de la recherche sur les transports urbains - répertoire = Urban Transportation Research Branch - directory, par/by L. Suen, B.A. Smith et/and L.A. McCoomb, Transports Canada, Direction de la recherche sur les transports urbains/Transport Canada, Urban Transportation Research Branch.

☒ Economic feasibility of a magnetically levitated (MAGLEV) transportation system in the Canadian corridor, interim report, by R.W. Lake et al., Queen's University, Canadian Institute of Guided Ground Transport. TP 1937

☒ The economics of urban goods movement, (Urban goods movement report series, vol. 10), by R.K. House & Associates Ltd. and Clayton, Sparks & Associates Ltd. TP 2186

The economics of urban transportation, by Mark W. Frankena, University of Western Ontario. TP 1927

☒ EMME, par/by Université de Montréal, Centre de recherche sur les transports:
- Computer system for urban transportation planners, TP 2031
- Équilibre multimodal = Multimodal equilibrium, summary report. TP 2032
- Systems programmer's guide. TP 2033, 2034
- Graphics programs user's guide = Guide de l'utilisateur des programmes graphiques. TP 2035
- Command language reference manual. TP 2036
- Manuel de référence du langage de commandes. TP 2036F

Étude The Shopper Free-Bus, Vancouver, par le Service Technique, ville de Vancouver. TP 2051F

Evaluating the potential of a radio-linked signaling system for Urban Transit Applications - 2 volumes, by Urban Transportation Development Corporation. TP 2013, 2014

An evaluation of the mini-scheduler demonstration project, by Province of Alberta, Department of Transportation. TP 2019

Evaluation of urban trucking rationalization in Vancouver, phase I and phase II, (Urban goods movement report series, vol. 5) by K.W. Hewett and K.G. Denike, Swan Wooster Engineering Co. Ltd. TP 1836

An exploratory study into recooling alternatives for Maglev isochoric dewar operation, by CTF Systems Inc. TP 2536

☒ A feasibility study of the introduction of larger capacity intercity buses, by N.D. Lea and Associates. TP 2053

☒ Flexible fare collection through multiple-ride tickets: a case evaluation of technology & implementation, by Precursor Ltd. TP 1979

☒ Framework for urban goods movement information in Canada (Urban goods movement report series, vol. 9), by TEE Consulting Services Inc. TP 1837

Glaciation différentielle des tabliers de ponts = Differential icing on bridge decks, rapport sommaire/summary report, par/by R.S. Jagla et/and I.K. Upjohn, Fenco Consultants Ltd. TP 2844

☒ Implementation of equilibrium traffic assignment with graphical output in the GVRD bimodal model, by Caroline Fisk and Linda James-Lefebvre, Universite de Montréal, Centre de recherche sur les transports. TP 1941

Innovative paratransit vehicle - the GSM taxi, by Guillon, Smith, Marquart & Associates. TP 2688

☒ Intercity passenger transport energy efficiency: data base and case study, preliminary final report, by Ata M. Khan, Carleton University, Dept. of Civil Engineering. TP 2067

☒ Kitchener-Waterloo travel study, vol. 1 - Study findings; vol. 2 - Data base, by Read, Voorhees & Associates Ltd. TP 1980, 1981

☒ MTC runcutting improvements, User guide, by Sage Management Consultants Ltd. TP 2233

☒ Marché potentiel des autobus de grande capacité au Canada, par De Leuw Cather Canada Ltd. TP 1990F

☒ The mini-scheduler: a preliminary evaluation, by Toronto Transit Commission. TP 2016

Mississauga, Ontario, off-peak transit survey analysis, by Presage Research Ltd. TP 2058

The Mississauga Transit demonstration of the Automatic Bus Passenger Information concept: Easy Rider, by IBI Group and Josef Kates Associates Inc. TP 2048

☒ (Report on) Monitoring vehicle and axle weights, by Roads and Transportation Association of Canada. TP 1940

☒ New Brunswick van pooling demonstration project, phase I activities, by ADI Ltd. TP 2390

Off-line signal system optimization package, SSTOP - 2 volumes, by McMaster University, Traffic Research Group. TP 2029

☒ Ottawa River Parkway contra flow bus lanes, working paper = Voies de la promenade de la rivière des Outaouais réservées aux autobus à contre-courant, document de travail, by/par De Leuw Cather Canada Ltd. TP 1798

☒ Overview of transit scheduling experiments, working paper, by Scott Stewart. TP 1942

Pavement deflection testing vehicle: a feasibility study, by A.T. Bergan, Clayton, Sparks & Associates Ltd. TP 2846

☒ The potential for high capacity buses in Canada, working paper, by De Leuw Cather Canada Ltd. TP 1990

A programmer analyst's guide to the MIT/UMTA D-A-R simulation program, by Presage Research Ltd. TP 1982

☒ Projets de démonstration sur l'optimisation de la circulation, Montréal & Québec, rapport final, par De Leuw Cather Canada Ltd. TP 2030F

Research and development of multi-motor A.C. propulsion systems, final report, by S.B. Dewan et al., University of Toronto. TP 2763

☒ A review of automobile stock models, by Presage Research Ltd. TP 1877

☒ A review of Canadian urban passenger mode choice models, by Presage Research Ltd. TP 2202

A review of the experience and activities of the Urban Transportation Research Branch, 1974-1979, by Transport Canada, Urban Transportation Research Branch. TP 2189

RUNCUT: The University of Ottawa runcutting program, by Louis G. Birta, University of Ottawa. TP 1943

Revue des réalisations et des activités de la Direction de la recherche sur les transports urbains, 1974-1979, par Transports Canada, Direction de la recherche sur les transports urbains. TP 2189F

☒ SSTOP demonstration program for the city of Cambridge, by IBI Group. TP 2045

☒ Service performance analysis and reporting system (SPARS) demonstration project, by Metropolitan Area Planning Commission, Halifax, (N.S.). TP 2020

The Shopper Free-bus study, Vancouver, by City of Vancouver, Engineering Dept. TP 2051

Structural analysis of proposed Maglev vehicle body shell, by W.F. Hayes, National Research Council. TP 2678

☒ A study of consolidated building receiver demonstration, executive summary, by TEE Consulting Services Inc. TP 1892

☒ Study of the hydraulic properties of coarse particles of metallurgical coal when transported in slurry form through pipelines of various diameters, by D.B. Haas et al., Saskatchewan Research Council. TP 2597

☒ Subdivision design guidelines to facilitate transit services, working paper, by Lavalin Inc. TP 2188

☒ System analysis of airport demand responsive transport (DRT), by Transport Canada, Strategic Studies Branch and Urban Transportation Research Branch. TP 953

☒ Taxi dispatch report series - 4 volumes:
  vol. 2: A case study of a manual dispatch system for a taxi company, Intercab Inc., of Mississauga, by International Aeradio, University of Toronto/York University Joint Program in Transportation. TP 2081
  vol. 3: System method study of an automated taxi dispatch and control system, Ottawa, by Digital Methods Ltd. TP 1718
  vol. 5: Adaptation of dial-a-ride operational algorithms to shared-ride taxi operation, by Presage Research Ltd. TP 1928
  vol. 6: Annotated bibliography on demand responsive scheduling systems, by University of Toronto/York University Joint Program in Transportation. TP 1898

☒ Traffic optimization demonstration projects, Montreal-Quebec, final report, by De Leuw Cather Canada Ltd. TP 2030

Le transport urbain au Canada: une analyse économique, par Mark W. Frankena, University of Western Ontario. TP 1927F

Truck back-up obstacle detector, final report, by Analytic Systems Ware Ltd. TP 2575

☒ Urban goods movement research: a framework and results (Urban goods movement report series, vol. 1), by W.G. Wood. TP 1834

☒ Urban goods movement research: Canadian experience in the seventies, by W.G. Wood, L. Suen and A. Ebrahim, Transport Canada, Urban Transportation Research Branch. TP 2355

Urban transport service innovations, special report 184, by Transportation Research Board, National Academy of Sciences. TP 2041

☒ Urban Transportation Research Branch - directory = Direction de la recherche sur les transports urbains - répertoire, by/par L. Suen, B.A. Smith and/et L.A. McCoomb, Transport Canada, Urban Transportation Research Branch/Transports Canada, Direction de la recherche sur les transports urbains. TP 2185

☒ A vanpooling demonstration project in Manitoba: the concept, feasibility of the project and site selection, by Underwood McLellan (1977) Ltd. TP 2421

☒ Voies de la promenade de la rivière des Outaouais réservées aux autobus circulant à contre-courant, document de travail = Ottawa River Parkway contraflow bus lanes, working paper, par/by De Leuw Cather Canada Ltd. TP 1798

☒ Year 1990: transit ridership forecasts, by Presage Research Ltd. TP 2204

1981

Bascules de pesage dynamique, par A.T. Bergan, Association des routes et transports du Canada. TP 3214F

Battery research and development in Canada = Recherche et développement au Canada: batteries, by/par R.F. Webb, R.F. Webb Corporation. TP 3110

Commercial vehicle driver performance improvement study - phase 1, by P.F. Inglis, DeLCan Ltd., TP 2847

The double-deck bus: a transport and industrial opportunity for Canada, by R.F. Webb, R.F. Webb Corporation. TP 3181

Dynamic weigh-in-motion scales, by A.T. Bergan, Roads and Transportation Association of Canada. TP 3214

Feasibility study of ICTS in airport applications, by D.F. Williamson and R. Giles, Urban Transportation Development Corporation. TP 3011

Flexible base skidder, development and evaluation, by D. Jones, Jones, Kirwan & Associates Ltd., TP 2971

Implantation de l'Aérobac: étude préliminaire de développement, par R.F. Alepin, R.G. Paris et A. Laroche-Ciurariu, SNC Inc. TP 2785F

Intermodal efficiency of the Vancouver-Victoria bus/ferry service and a baseline design for a Canadian double-deck bus, by T. Partridge, Pacific Coach Lines, and T. Smith, Transportation Development Centre. TP 3387

Microprocessor controlled display, by J.G. Moxham, Epsilon Data Systems Ltd. TP 3292

Recherche et développement au Canada: batteries = Battery research and development in Canada, par/by R.F. Webb, R.F. Webb Corporation. TP 3110

Research on the Sail Rail compliant surface air bearing, by M.J. Hinchey, University of Toronto Institute for Aerospace Studies. TP 2817

Study of an analytical model of the homopolar linear synchronous motor, by G.R. Slemon, University of Toronto. TP 2856

Superconductive energy storage for trains, by A.R. Eastham, G.W. English and D.M. Pringle, Queen's University, Canadian Institute of Guided Ground Transport. TP 3200

Wheelchair access system for intercity buses, by D.K. Woods and T. Van Humbeck, TES Ltd. TP 3186

1982

Aérobac AB 7: étude de faisabilité technique, rapport final, par P.F. Alepin, D. Gawish et R.G. Paris, SNC Inc. TP 3507F

Aérobac AB 7: étude de faisabilité technique, rapport sommaire, par P.F. Alepin, D. Gawish et R.G. Paris, SNC Inc. TP 3508F

Aérobac AB 7: technical feasibility study, summary report, by P.F. Alepin, D. Gawish and R.G. Paris, SNC Inc. TP 3508E

Flywheel experimental program — development of a hybrid drive line, by D.J. Taylor and P. Veraart, Urban Transportation Development Corporation. TP 3620E

High capacity bus development in Europe: trip report, March 1982, by R.F. Webb, R.F. Webb Corporation. TP 3683

Non-petroleum energy sources for urban transit, final report, by L. Sims and S. Hayto, IBI Group. TP 3684

Air Technology

1971 - 1973

Air cargo technology investigation, summary report, by Aviation Planning Associates. TP 1282

☒ Analysis of the environmental and ecological effects of the demonstration STOL service between Montreal and Ottawa, by R. Dixon Speas Associates Limited.

☒ Analysis of the environmental effects of the DHC-7 STOL service at Montreal, by R. Dixon Speas Associates Limited.

☒ An appraisal of a possible commuter/feeder application of STOL at a major urban airport, by Kates, Peat, Marwick & Co.

☒ The effects of introducing STOL service on Malton development, by Aviation Planning Services Ltd.

☒ Feasibility of STOL aircraft service within the North Shore region of Quebec, final report, by Sores Inc.

☒ Newfoundland STOL study, by Kates, Peat, Marwick & Co.

☒ Passenger survey, Airwest Airlines STOL operations: Vancouver-Victoria, Vancouver-Nanaimo, by Aviation Planning Services Ltd.

☒ The potential for feeder commuter application of STOL air transportation in the lower coastal region of British Columbia, by Aviation Planning Services Ltd.

☒ Potential for STOL aircraft service in B.C. coastal region, by Aviation Planning Services Ltd.

☒ STOL market research, analysis and forecasting program for the proposed STOL demonstration service between Ottawa and Montreal, by Market Facts of Canada Ltd.

☒ Study of regional application of STOL, final report, by Kates, Peat, Marwick & Co.

☒ Toronto-New York/Montreal-New York STOL study, by Aviation Planning Services Ltd.

1974 - 1976

Evaluation of Airtransit operating and financial results, by Aviation Planning Associates. TP 1413

☒ Evaluation of comparative cost estimates for STOL and CTOL air carrier operations, by Aviation Planning Associates. TP 1414

☒ STOL demonstration Montreal-Ottawa 1974-76 data summary, working paper, by TDA. TP 639

1977

☒ Final report on crashworthiness of light aircraft structures, by University of Toronto Institute for Aerospace Studies. TP 1029

☒ Minimum safe altitude warning project, design specifications, by Digital Methods Ltd. TP 1267

☒ Pressures inside a room subjected to sonic boom, by Nabil N. Wahba, University of Toronto Institute for Aerospace Studies. TP 1592

STOL demonstration service highlights of operational experience, working paper, by TDA. TP 1295

1978

Aircraft energy management system - phase I, vol. 1 - Lockheed L-1011, by Computing Devices Company. TP 1314

Démonstration ADAC Montréal-Ottawa, 1974-1976, I, rapport sommaire = STOL demonstration Montreal-Ottawa, 1974-1976, I, summary report, par/by CDT/TDC. TP 1686

Long range planning implications of technological development, working paper, by TDC. TP 1572

STOL demonstration Montreal-Ottawa, 1974-1976, 3 volumes, by TDC:
- I: Summary report = rapport sommaire. TP 1686
- II: Main report. TP 1687
- III: Data report. TP 1688

1979

☒ Air cargo gateway airports, final report, by R.S. Wallace and Associates Ltd. TP 2201

Aircraft Energy Management System, phase I, by Computing Devices Company. TP 1893

Analyse des pertes de glycol constatées durant le processus de récupération des solutions glycolées de dégrivage, rapport sommaire = Analysis of shrinkage in volume of glycol in de-icing fluid recovery systems, summary report, par/by LGL-Love. TP 2400

Analysis of shrinkage in volume of glycol in de-icing fluid recovery systems, final report, by LGL-Love. TP 2278

Étude sur les collisions aviaires aux aéroports canadiens - 1979, rapport sommaire, par T. Smith et D. Iwanycky, CDT. TP 2439F

☒ Feasibility study on aircraft gross weight and centre of gravity measurement, by T E S Limited. TP 2142

Fibre optic weight sensor, summary report, by DSL Dynamic Sciences Ltd. TP 2543

Fibre optic weight sensor, final report, by DSL Dynamic Sciences Ltd. TP 2544

Instrument pour la pesée par fibres optiques, par DSL Dynamic Sciences Ltd. TP 2543F

Instrument ultrasonique pour la pesée, rapport sommaire, par T E S Ltd. TP 2427

☒ Potential of fibre optics for transportation applications, by Interbase Inc. TP 1804

☒ Study of bird strikes at Canadian airports - 1979, summary report, by T. Smith and D. Iwanycky, TDC. TP 2439

Study of bird strikes at Canadian airports - 1979, risk and statistical analysis, by T.E. Geehan and W.G. Wood, Hickling-Smith Inc. TP 2440

Study of bird strikes at Canadian airports - 1979, main report, by R.E. Agar and E.P. Heybroek. TP 2441

☒ Study of bird strikes at Canadian airports - 1979, site reports - 14 volumes, by R.E. Agar and E.P. Heybroek, Aviation Planning Associates:
    Toronto International Airport. TP 2442
    Vancouver International Airport. TP 2443
    Calgary International Airport. TP 2444
    Winnipeg International Airport. TP 2445
    Ottawa International Airport. TP 2446
    Halifax International Airport. TP 2447
    Edmonton International Airport. TP 2448
    Montreal (Dorval) International Airport. TP 2449
    Windsor Airport. TP 2450
    Thunder Bay Airport. TP 2451
    Regina Airport. TP 2452
    Hay River Airport. TP 2453
    CFB Comox. TP 2454
    CFB Bagotville. TP 2455

Study of bird strikes at Canadian airports - 1979, compendium of visit reports of special interest, by R.E. Agar and E.P. Heybroek, Aviation Planning Associates. TP 2456

☒ A study to determine the feasibility of an aircraft gross weight and centre of gravity measurement system, by DSL Dynamic Sciences Ltd. TP 2143

TDC gas generator turbine research program, 1978-1979, executive summary, by U. Okapuu, Pratt & Whitney Aircraft of Canada Ltd. TP 2330

TDC gas generator turbine research program, 1978-1979, final report, by U. Okapuu, Pratt & Whitney Aircraft of Canada Ltd. TP 2335

La turbine du générateur de gaz de CDT, programme de recherche, 1978-79, rapport sommaire, par U. Okapuu, Pratt et Whitney Aircraft du Canada Ltée. TP 2330F

Ultrasonic weight sensor, final report, by T E S Ltd. TP 2425

Ultrasonic weight sensor, summary report, by T E S Ltd. TP 2426

☒ Winnipeg air freight waybill survey, by J. Rostenne, Lenasco Ltd. TP 1906

1980

Aircraft annoyance evaluations using field and laboratory simulation techniques, by G.W. Johnston and A.A. Haasz, University of Toronto, Institute for Aerospace Studies. TP 2783

Crashworthiness of light aircraft structures, final report, by R.C. Tennyson, J.S. Hansen, H. Teichman et al., University of Toronto, Institute for Aerospace Studies. TP 2616

Energy efficient aircraft study, summary report, by P.H. Whyte, Canadair Ltd. TP 2687

Energy efficient aircraft study — phase II, summary report, by P.H. Whyte, Canadair Ltd. TP 3021

Energy efficient STOL transport aircraft — phase I, findings and research recommendations, summary report, by B. Eggleston, de Havilland Aircraft of Canada Ltd. TP 2793

Étude d'avions à haut rendement énergétique, sommaire exécutif, par P.H. Whyte, Canadair Ltd. TP 2687F

Final sonic boom report for period 1 April, 1977, to 31 March, 1980, by I.I. Glass and H.S. Ribner, University of Toronto Institute for Aerospace Studies. TP 2599

Potential benefits of a wake vortex visualization system, final report, by M. Stade, Aviation Planning Services Ltd. TP 3051

TDC gas generator turbine research program 1979-1980, summary report, by U. Okapuu, Pratt & Whitney Aircraft of Canada Ltd. TP 2685

La turbine du générateur de gaz du CDT, programme de recherche, 1979-1980, rapport sommaire, par U. Okapuu, Pratt et Whitney du Canada Ltée. TP 2685

☒ Use of fibre optics in Transport Canada communications, MPB Technologies Inc. TP 2481

1981

Air transport of wheelchair batteries, by W.F. McCaffrey, TES Ltd. TP 3210E

Assessment of the potential of cargo gateway airports, final report, by R.S. Wallace et al., R.S. Wallace & Associates Ltd. TP 3356

Assessment of the potential of cargo gateway airports, summary report, by R.S. Wallace et al., R.S. Wallace & Associates Ltd. TP 3355E

The costs of aircraft accidents in Canada, final report, by M. Kieran, R. Allingham and S. Lieff, Peat, Marwick & Partners. TP 3496E

The costs of aircraft accidents in Canada, summary report, by M. Kieran, R. Allingham and S. Lieff, Peat, Marwick & Partners. TP 3497E

Les coûts d'accidents d'avions au Canada, rapport sommaire, par M. Kieran, R. Allingham et S. Lieff, Peat, Marwick & Partners. TP 3497F

The market potential for sea/air cargo service via Mirabel, final report, by R.S. Wallace and F.E. Petrie, R.S. Wallace & Associates Ltd. TP 3477E

The market potential for sea/air cargo service via Mirabel, summary report, by R.S. Wallace and F.E. Petrie, R.S. Wallace & Associates Ltd. TP 3478E

Mirabel transhipment centre for sea/air cargo, by M. Tapiero, Transportation Development Centre, and R.S. Wallace and R.S. Bugatsch, R.S. Wallace & Associates Ltd. TP 3092E

Le programme de recherche du CDT sur la turbine du générateur à gaz: rapport sommaire 1980-1981, par U. Okapuu, Pratt et Whitney du Canada Ltée. TP 2149F

Protective container for wheelchairs: feasibility study, by G. Nicklin, Davis Engineering Ltd. TP 3180

Some factors influencing modal choice of Winnipeg shippers and consignees, final report, by K.R. Weins, InterGroup Consulting Economists Ltd. TP 3711E

TDC gas generator turbine research program: summary report 1980-1981, by U. Okapuu, Pratt & Whitney Aircraft of Canada Ltd. TP 3149E

Use of the UTRC 8 kW wind turbine as a stand-alone power supply for UNAVCOM, by J.C. Asher and F. Tadros, Pratt & Whitney Aircraft of Canada Ltd. TP 3100E

Marine Technology

1971 - 1973

☒ Feasibility of air cushion vehicle operation across Cabot Strait — phase I, by N. Howard Johnson and Simon Bergen-Henengouwen, TDA.

☒ Lake Melville ice research, 1972-73, by Memorial University of Newfoundland, Faculty of Engineering and Applied Science, Ocean Engineering Group.

☒ Strait of Belle Isle transportation study, by A.B. Cammaert et al., Memorial University, Faculty of Engineering and Applied Science.

1974 - 1976

☒ Aéroglisseur Voyageur: programme expérimental d'exploitation sur la basse Côte-Nord - 4 volumes, par Agence Maritime Inc.

☒ Bell Voyageur 002-ACV: cold weather evaluation, by C. Preston, TDA.

☒ Bell Voyageur 002-ACV: engineering and commercial evaluation, by C. Preston, TDA.

☒ Bell Voyageur 002-ACV: environmental assessment, by F.F. Slaney and Company and TDA.

☒ Bell Voyageur 002-VCA: évaluation commerciale et technique, par C. Preston, CDT.

☒ Bell Voyageur 002-VCA: résumé du programme d'évaluation, par CDT.

☒ Bell Voyageur 002-ACV: summary of evaluation program, by TDA.

☒ Experimental study of the application of VHF radiometry for the remote measurement of sea-ice thickness, by James D. Robar, SED Systems Ltd. TP 254

☒ Forecast of ship trends and characteristics as related to dry dock facilities in Canada, by Swan Wooster Engineering Co.

☒ Ice conditions: air cushion vehicle ice breaking trials, Hover-Jak and Terracross rafts: Toronto, January 16 - February 22, 1974, by David F. Dickins, TDA.

☒ Methods for predicting forces encountered by propellers during interaction with ice, by Artec Canada Ltd. TP 293

Perspectives de changement dans la manutention des marchandises aux ports canadiens, par CDT.

☒ Programme de démonstration du véhicule à coussin d'air Voyageur dans la région de la Basse Côte-Nord - 4 volumes, par Bell Aerospace Canada.

Prospective changes for the handling of commodities in Canadian ports, by TDA.

☒ A report on the Canadian Coast Guard evaluation of the Bell Aerospace Canada Voyageur Hovercraft (Voyageur trials, phase II), by Ministry of Transport, ACV division.

☒ Results of full scale field trials of ACT-100 with CCGS Alexander Henry, by R.Y. Edwards Jr. TP 862

☒ Voyageur air cushion vehicle: lower North Shore demonstration program - 4 volumes, by Bell Aerospace Canada.

☒ Voyageur air cushion vehicle: lower North Shore demonstration program, by Maritime Agency Inc.

☒ Voyageur ACV trials on the Mackenzie Delta: environmental effects two years later, by TDA. TP 233

1977

☒ The ACV icebreaking bow development program: an overview and status report, by J.D. Hearnshaw, TDC. TP 818

☒ Combined cycle gas turbine plant for marine propulsion - phase I, program definition, by G.H. Robertson, Pratt & Whitney Aircraft of Canada Ltd. TP 1129

☒ Development of a comprehensive theory for selecting design ice forces acting on cylindrical and conical structures, final report, by F.G. Bercha and Associates Ltd. TP 1397

☒ Development of a remote sea-ice thickness sensor: phase 1, evaluation of potential sea-ice thickness measuring techniques, by Innovative Ventures Ltd. TP 1276

☒ Development of a remote sea-ice thickness sensor: part 1, a review with analysis of candidate sensors, by S.Y.K. Tam, MPB Technologies Inc. TP 1277

☒ Iceater I: adaptation, operation, testing and evaluation of Arctic Systems Limited ACV Iceater I for icebreaking trials in conjunction with commercial vessels and CCGS Alexander Henry (Griffon) during the winter 1976-77 (Phase II), by Arctic Systems Limited. TP 1106

☒ Mathematical analysis of icebreaking by air cushion platforms, by Donald Carter. TP 1238

☒ Model tests in support of Alexander Henry/ACT-100 concept development, by R.Y. Edwards Jr., R. Abdelnour, TDA. TP 867

☒ Options de transport par mer pour le commerce maritime international canadien, rapport sommaire, par Services de Transports de l'Alcan Ltée. TP 1254F

☒ Results of full scale trials in ice to further assess the icebreaking capability of CCGS Wolfe, by J.R. Allan, Arctec Canada Ltd. TP 1239

☒ Shipping options for Canadian international deep-sea trade, summary report, by Alcan Shipping Services Ltd. TP 1254

☒ Shipping options for Canadian international deep-sea trade - 4 volumes, by Alcan Shipping Services Ltd.:
    part 1: Commercial analysis. TP 1301
    part 2: Direct costs and benefits of a hypothetical Canadian fleet and a balance of payments analysis. TP 1302
    part 3: Selection of commodity routes. TP 1303
    part 4: Costing model computer program, user's manual. TP 1304

1978

☒ Bibliography of remote sea-ice techniques, by Innovative Ventures Limited. TP 1467

☒ Comparative study of a ferry service by air cushion vehicle and ice-strengthened ferry between Matane/Baie-Comeau/Godbout, summary report = Étude comparée d'un service de traversiers maritimes par aéroglisseurs et traversiers brise-glace, Matane/Baie-Comeau/Godbout, rapport sommaire, by/par SNC Inc. TP 1883

☒ Compilation and analysis of recent icebreaking model test data of a world-wide variety of hull forms, by R.Y. Edwards, Arctec Canada Ltd. TP 1294

☒ A demonstration of air cushion technology potential to extend harbour shipping seasons, HL-301 at Churchill, October 1978 (also known as: A demonstration of shipment, assembly and operation of an air cushion icebreaking platform for potential support of extended shipping seasons at a remote harbour, HL-301 at Churchill, October 1978), by R.G. Wade. TP 1912

Design and operation of an ice tribometer, test report, by Arctec Canada Limited. TP 1789

Development of a remote sea-ice thickness sensor, by S.Y.K. Tam, MPB Technologies Inc.:

vol. 1: Antenna and horizontal resolution studies. TP 1573
vol. 2: Electronics design. TP 1574

Étude comparée d'un service de traverses maritimes par aéroglisseurs et traversiers brise-glace, Matane/Baie-Comeau/Godbout, rapport final, par SNC Inc. TP 2297

Étude comparée d'un service de traversiers maritimes par aéroglisseurs et traversiers brise-glace, Matane/Baie-Comeau/Godbout, rapport sommaire = Comparative study of a ferry service by air cushion vehicle and ice-strengthened ferry between Matane/Baie-Comeau/Godbout, summary report, par/by SNC Inc. TP 1883

☒ Investigation of strength aspects for the extension of service of Great Lakes type bulk carriers to the "Gulf Corridor" for the full Great Lakes season, by D.W. Robinson. TP 1813

☒ Results of tests conducted using ships of two different breadths to push an air cushion transporter in ice, final report, by M. Dunne, Arctec Canada Ltd. TP 1266

☒ Testing of prototype circuitry for M.V. Arctic, final report, by German & Milne. TP 1449

Wave climate analysis for selected locations in the Gulf of St. Lawrence and Lake Superior — 7 volumes, by W.F. Baird. TP 1775

☒ Wave propagation in ice-covered waters, by Donald Carter. TP 1522

☒ YPASS propulsion system evaluation, by R.Y. Edwards, R.J. Allan, Arctec Canada Ltd.

1979

☒ Analyses of air cushion icebreaking devices attached to ships, summary report (1978), by S. Morita, The de Havilland Aircraft of Canada Ltd. TP 1773

☒ Canadian Shipbuilding and Ship Repairing Association data bank proposal, by Dalhousie University. TP 2026

Combined epicyclic/parallel shaft 50,000 shp gearbox for marine propulsion, by APE Allen Gears Ltd. TP 1822

☒ Design study for an ACV platform icebreaking attachment for Canadian Coast Guard ships, by Hoverlift Systems Ltd. TP 2141

☒ Development of a research program for improving Arctic marine transportation technology — 3 volumes, by Arctec Canada Limited. TP 2003, 2004, 2005

Development of a research program for improving Arctic marine transportation technology, summary report, by Arctec Canada Limited. TP 2006

☒ Evaluation of potential sea-ice thickness measuring techniques, by Surendra Parashar. TP 1240

☒ Guide to marine transportation information sources, by Margaret C. Mackay and Ann. L. Poole, University of Toronto/York University Joint Program in Transportation. TP 2431

☒ High efficiency combined cycle gas turbine plant for marine propulsion - 5 volumes, by Pratt and Whitney Aircraft of Canada Ltd. and German & Milne Inc. TP 2380:
  vol. 1: Phase 1, Program definition.
  vol. 2: Phase 2, Investigation and data collection.
  vol. 3: Phase 3, System definition.
  vol. 4: Phase 4, System analysis.
  vol. 5: Final report and executive summary.

☒ Model tests for examining the behaviour of an ACIB in level ice, by R. Abdelnour and P. Noble. TP 1774

M.V. Arctic instrumentation and data collection system for ship operations in ice, system operating and user's manual - 2 volumes, by German & Milne Inc. TP 2217

M.V. Arctic instrumentation and data gathering system for ship operations in ice, system operating and user's manual, summary report, by German & Milne Inc. TP 2218

A study of iceberg detection for marine navigation, final report, by C.P. Benedict and J.C.E. Hall, ICE Engineering Ltd. TP 2409

1980

ACV propeller blade erosion: a study of protection methods for CCG hovercraft, by Hanson Materials Engineering (Western) Ltd. TP 2566

Air bubbler ice control experiment in Thunder Bay, by Lakehead Harbour Commission. TP 2657

Air cushion icebreaking bow development program, 1975-1978, summary report, by A.A. Hope, J. Udell and M. Tapiero, TDC. TP 1924

☒ Assessment of potential performance of a 45 MW marine superconducting motor, by International Research & Development Ltd. TP 2632

Canadian Shipbuilding and Ship Repairing Association infocentre project, by German & Milne Inc. TP 2794

Cargo brise-glace Arctic: projet d'évaluation scientifique, saisie de données (saison 1979-1980), rapport sommaire, par German & Milne Inc. TP 2641F

Current government-sponsored marine transportation research activity, by D. Hearnshaw et al., TDC. TP 2522

Détection des glaces flottantes, rapport sommaire, par C.P. Benedict and J.C.E. Hall, ICE Engineering Ltd. TP 2414F

☒ Development of a remote sea-ice thickness sensor, by S.Y.K. Tam, J.M. Keelty, G. Riedel and I.P.W. Sinclair, MPB Technologies Inc.:
  vol. 1: Simulation experiments on the experimental prototype. TP 2634

vol. 2: Electronics report. TP 2635

Development of a vortex-stabilized arc source for marine applications, by MPB Technologies Inc. TP 2662

☒ Evaluation of options for the processing of sea-ice thickness measurements, by J.M. Keelty and J. Brana, MPB Technologies Inc. TP 2857

☒ Ice force math model investigations, by Arctec Canada Ltd. TP 2596

Ice rules for propellers and propeller shafting, by Arctec Canada Ltd. TP 2556

Mise au point de la technique de déglaçage par plate-forme à coussin d'air, 1975-1978, rapport sommaire, par A.A. Hope, J. Udell et M. Tapiero, CDT. TP 1924

M.V. Arctic scientific evaluation project: data collection activity (1979-1980 season), summary report, by German & Milne Inc. TP 2641

Operational maintenance report for M.V. Arctic data acquisition system, 1979 season - phases I-V, by J. Stirling, German and Milne Inc. TP 2617

Operational maintenance report for M.V. Arctic data acquisition system, 1979 season - phase VI, refurbishing, by J. Stirling. TP 2690

Polar class ice-load and acceleration forecasts, final report, by Arctec Canada Ltd. TP 2595

A preliminary analysis of dynamic ice rupture by hovercraft, by Marvin Shinbrot, Université de Montréal, Centre de recherche de mathématiques. TP 2461

Protection of propellers in ice, vol. 1: assessment of protection schemes, by M. George, F. Livingston, T.C. Currie, Davis Engineering Ltd. TP 2704

A review of steel properties at low temperatures, S.H. Iyer et al., Fenco Consultants Ltd. TP 2717

Sea-ice thickness radar measurements in the Beaufort Sea, by J.M. Keelty and S.Y.K. Tam, MPB Technologies Inc. TP 2677

Y-PASS development: resistance propulsion, towing and side force measurements with model 303C, by D.C. Murdey and M.W. Harrison, National Research Council. TP 2897E

Strength requirements for operating Great Lakes type bulk carriers in the Gulf Corridor to specific dates, by Lloyd's Register of Shipping. TP 2618

A study of iceberg detection for marine navigation, summary report, by C.P. Benedict and J.C.E. Hall, ICE Engineering Ltd. TP 2414

1981

Concepts for icebreakers with integral fluid cushion bow, F.R. Livingstone and M.F. George, Davis Engineering Ltd. TP 3405E

Concepts for icebreaker with integral air cushion bow, by S. Malmberg et al., Canfin Arctic Consultants Ltd. TP 3406E

☒ Evaluation of a Precise Radar Navigation System (PRANS), summary report, by A.A. Hope, TDC. TP 2980

Listing of Canadian marine R&D projects - 1980, by Sandra Murphy-Wong. TP 3169

☒ M.V. Arctic hull vibration study, by A. Hancock, Lloyd's Register of Shipping. TP 2881

M.V. Arctic instrumentation and data collection system for ship operations in ice, System operating and user's manual - 3 volumes, by D.J. Boteler, A. Benjamin, F.G. German, Fenco Consultants Ltd. TP 3097

M.V. Arctic operational evaluation, by A. Stockdale, Maricon Ltd. TP 2956

Nickel plating of Voyageur ACV propeller blades to improve their erosion resistance, by G.A. Malone, Bell Aerospace Canada. TP 3147

PRANS trials: evaluation of a Precise Radar Navigation System, final report, by G. Stiles, R.O. Hewitt and C.O. McHale, Dominion Marine Association. TP 2800

Radio frequency circuit design for automatic data processing of radar signals of remote sea-ice thickness sensor, final report, by G. Grandchamp and S. Geller, MPB Technologies Inc. TP 3341

Winter 1981 trafficability tests of USCGC Polar Sea, volume IXA: ice induced vibration measurements and development of a model for icebreaking excitation forces, by I.F. Glen et al., Arctec Canada Ltd. TP 3617

1982

Concepts for the integration of a fluid cushion into the bow of a ship, by N. Dadachanji and P. Markham, German & Milne Inc. TP 3407E

M.V. Arctic 1981 late season data collection and instrumentation, 2 volumes, by H. Blount, I. Glen and M. Steele, Arctec Canada Ltd. TP 3634

M.V. Arctic 1981 season refurbishing and maintenance of the data gathering instrumentation system, final report, by J.F. Stirling, German & Milne Inc. TP 3633

Multimodal Technology

1971 - 1973

☒ Airport access in Canada, by V. Setty Pendakur, TDA.

☒ Economic study of transportation in the Mackenzie River Valley - 2 volumes, by Travacon Research Limited.

☒ Edmonton-Calgary corridor transportation study, working papers, TDA.

The impact on Canadian transportation of forecast changes in the export of primary products, by Canadian Pacific Consulting Services Ltd.

☒ The impact on Canadian transportation of possible changes in Canada's economic relationship with the U.S., by Canadian Pacific Consulting Services Ltd.

☒ The impact of energy futures on the Canadian transportation sector, by Canadian Resourcecon Limited. TP 2223

☒ Inter-city travel, demand and modal split model, interim report, by Kates, Peat, Marwick & Co.

☒ Newfoundland transportation and resources: transportation needs by resource sector, by University of Ottawa, Center for Regional Studies.

1974 - 1976

Arctic oil and gas transportation: summary and 1975 update = Transport du pétrole et du gas naturel de l'Arctique: étude sommaire et mise à jour pour l'année 1975, by/par TDA/CDT. TP 125

☒ Les courants d'exportation entre les régions canadiennes et les pays étrangers selon les modes de transport, par CDT.

☒ Edmonton-Calgary corridor passenger and travel data summary, by B. Trnavskis, Edmonton-Calgary Corridor Transportation Study Group.

☒ Edmonton-Calgary corridor transportation study, final report, by TDC and Alberta Transportation. TP 650

☒ The export flows between the regions of Canada and foreign countries by mode of transport, by TDA.

☒ Mode choice for intercity passenger travel Montreal-Ottawa, working paper, by TDA. TP 234

☒ Pacific rim access project - traffic forecasts and network flow analysis, working paper, by TDA. TP 2220

Report on qualitative research to determine transportation service attributes which influence travellers' mode decisions, by Bruce Mallen & Associates. TP 212

Technologie et productivité du transport de passagers, par CDT. TP 295F

Technology and productivity in passenger transportation, by TDC. TP 295

Transport du pétrole et du gas naturel de l'Arctique: étude sommaire et mise à jour pour l'année 1975 = Arctic oil and gas transportation: summary and 1975 update, par/by CDT/TDA. TP 125

1977 - 1978

Flow-related problems in the distribution of Western Canadian coals, working paper, by H.G. Engineering Ltd. and Lemberg Consultants Ltd. TP 826

Freight mode selection in Canada, by Ronald E. Turner, Queen's University, Canadian Institute of Guided Ground Transport.

☒ Passenger and goods demand studies: a program outline, by Ewart, Temblay et Associés. TP 907

Passenger transportation between Montreal and Ottawa 1973-1976: an analysis of the impact of the Airtransit STOL demonstration service on the passenger volumes of other modes, including the private automobile, by Trevor Smith, TDC. TP 1409

1979 - 1980

☒ Air cargo gateway airports, by R.S. Wallace and Associates. TP 2201

Automobile accompanied rail travel to western Canada, the market potential, by T. Smith and B. Myers, TDC. TP 2591

☒ A comparison of modal energy consumption in intercity freight, phase I - feasibility study, by De Leuw Cather Canada Ltd. TP 2090

Étude de marché concernant un service de trains auto-couchettes vers l'ouest canadien, par T. Smith et B. Myers, CDT. TP 2591F

☒ Intermodal transportation for containers and trailers - an exploratory study, by Peat, Marwick and Partners. TP 2337

☒ Inventaire des non-utilisateurs de véhicules automobiles au Canada, document de travail, par Systems Approach Ltd. TP 1155F

☒ An inventory of the automobile non-user in Canada, working paper, by Systems Approach Ltd. TP 1155

☒ Winnipeg air freight waybill survey, by J. Rostenne, Lenasco Ltd. TP 1906

1981

The market potential for sea/air cargo service via Mirabel, final report, by R.S. Wallace and F.E. Petrie, R.S. Wallace & Associates Ltd. TP 3477E

The market potential for sea/air cargo service vis Mirabel, summary report, by R.S. Wallace and F.E. Petrie, R.S. Wallace & Associates Ltd. TP 3478E

Mirabel transhipment centre for sea/air cargo, by M. Tapiero, Transportation Development Centre, and R.S. Wallace and R.S. Bugatsch, R.S. Wallace & Associates Ltd. TP 3092E

Multimodal wheelchair securement/passenger restraint: prototype development, by U. Rutenberg, Les Designers Douglas Ball Inc. TP 3057E

Praticabilité technique et économique d'un système de trains autos-couchettes au Canada = Technical and economic feasibility of a Canadian auto train, par/by J.M. Rebelo, Société d'études et de consultation du Canadien Pacifique/Canadian Pacific Consulting Services Ltd. TP 3119

Some factors influencing modal choice of Winnipeg shippers and consignees, final report, by K.R. Weins, InterGroup Consulting Economists Ltd. TP 3711E

Transportation in Canada: a guide for travellers with special needs = Les transports au Canada: guide pour les voyageurs ayant des besoins spéciaux, 2nd edition/2ième édition, by/par Transportation Development Centre/Centre de développement des transports. TP 380

Transportation for the Mobility Handicapped

1974 - 1976

☒ Design of a tie-down mechanism for wheelchairs, by Ball Berezowsky Associates. TP 1252

Transportation for the handicapped: a framework for research and development, by Systems Approach Ltd. TP 879

1977

☒ An assessment of the human factors of transportation services for the handicapped, by Ben Barkow and Allan S. Berg. TP 726

Program of research and development relating to systems for the transportation handicapped, working paper, by TDC and Systems Approach Ltd.

1978

☒ Cadre de planification et guide de mise sur pied d'un service de transport pour handicapés, par Groupe IBI. TP 1962F

The design and development of a curb climbing electric wheelchair, by Ball Berezowsky Associates. TP 1500

☒ Documentation et évaluation du projet de démonstration du système de transport des adultes handicapés: transports des défavorisés, par Groupe IBI. TP 1263F

☒ Étude de faisabilité sur le transport des handicapés: établissement d'horaires et régulation par ordinateur, par PRO Data Services Ltd. TP 1261F

☒ Étude de faisabilité: concept du transport communautaire dans les régions rurales et les petites agglomérations urbaines (Transport des défavorisés), résumé administratif, par Systems Approach Ltd. TP 1489F

☒ Feasibility study of the mobility concept in rural and small urban areas (Transportation for the disadvantaged), executive summary, by Systems Approach Ltd. TP 1489

☒ Study of wheelchair lifts and Lift-eze prototype lift, by Wheelchair Mobile Services Ltd. TP 905

☒ Train access system for wheelchair passengers: definition of requirements, working paper, by R.F. Stapells & Associates Ltd. TP 1020

Transportation for the disadvantaged: a bibliography = Transport pour les handicapés: bibliographie, by/par Transport Canada, Urban Transportation Research Branch/Transports Canada, Direction de la recherche sur les transports urbains. TP 906

☒ Transportation for the handicapped: a feasibility study of computer-aided scheduling and dispatching, by PRO Data Services Ltd. TP 1261

☒ Transportation for the handicapped: a planning framework and implementation guidelines, by IBI Group. TP 1262

☒ Transportation for the handicapped: a documentation and evaluation of the Disabled Adult Transportation System demonstration project, by IBI Group. TP 1263

Wheelchair tie-down/passenger seat: prototype development, by Uwe Rutenberg, Douglas Ball Inc. TP 1821

1979

Analyse permettant l'identification et le dénombrement des personnes à mobilité réduite au Canada, rapport sommaire, par Systems Approach Ltd. TP 2084F

Barrier-free surface transportation terminals: design considerations, by D'Arcy O'Connell, Ball Berezowsky Associates. TP 1817

Data base study for the identification and quantification of transportation handicapped persons in Canada - 4 volumes, by Systems Approach Ltd.:

☒ vol. 1: Main study report. TP 2049
☒ vol. 2: Appendices A to F. TP 2082
☒ vol. 3: Appendix G. TP 2083
☒ vol. 4: Summary report = Rapport sommaire. TP 2084/2084F

☒ Étude de faisabilité: concept du transport communautaire dans les régions rurales et les petites agglomérations urbaines, (Transport des défavorisés), rapport technique, par Systems Approach Ltd. TP 1742F

Évaluation d'un dispositif d'immobilisation de fauteuil roulant, par Douglas Ball Inc. TP 2377F

☒ Feasibility study of the mobility club concept in rural and small urban areas (Transportation for the disadvantaged), technical report, by Systems Approach Ltd. TP 1742

Operational improvements for special transportation services for the handicapped, by Stanley Associates Engineering Ltd. TP 1995

☒ An overview of the workshop for operators of special transportation services for the handicapped, by D'Arcy O'Connell. TP 2025

☒ Profil des personnes défavorisées en matière de transport dans une région rurale du sud-ouest de l'Ontario, par University of Guelph, Rural Development Outreach Project. TP 1967F

☒ Profile of the transportation disadvantaged in a rural area of southwestern Ontario, by University of Guelph, Rural Development Outreach Project. TP 1967

Program plan for the Transport Canada advisory committee on the transportation needs of the handicapped, by Systems Approach Consultants Ltd. TP 2050

Programme d'améliorations des services de transport spéciaux destinés aux handicapés, par Stanley Associates Engineering Ltd. TP 1995F

☒ Recherche et développement portant sur le transport des personnes à mobilité réduite: cadre et résultats, par N.D. Lea & Associates Ltd. TP 2028F

Research and development in transportation for the mobility disadvantaged: a framework and results, by N.D. Lea & Associates Ltd. TP 2028

Système d'immobilisation de fauteuils roulants de conception convenant aux divers modes de transport, par Douglas Ball Inc. TP 2179F

☒ Train access systems for wheelchair passengers: overhead lift design, by C.F. English, Physico-Medical Systems Corp. TP 2086

☒ Transportation for the mobility disadvantaged: a bibliography = Transport pour les handicapés: bibliographie, by/par N.D. Lea & Associates Ltd. TP 2165

Transport de surface: conception de terminus accessibles aux handicapés, par D'Arcy O'Connell, Ball Berezowsky Associates. TP 1817F

☒ Transport pour les handicapés: bibliographie = Transportation for the mobility disadvantaged: a bibliography, par/by N.D. Lea & Associates Ltd. TP 2165

Wheelchair restraint system: design for multi-modal transportation, by Douglas Ball Inc. TP 2179

Wheelchair restraint system: performance evaluation, by Douglas Ball Inc. TP 2377

1980

Étude visant à déterminer la faisabilité de l'utilisation de taxis pour transporter les handicapés ambulatoires, par Groupe IBI. TP 2012F

A study to assess the feasibility of using taxi cabs for service to the ambulatory handicapped, by IBI Group. TP 2012

Systèmes d'embarquement de personnes handicapées voyageant par train, rapport intérimaire, par CDT. TP 2513F

Train access system for wheelchair passengers, status report, by TDC. TP 2513

1981

Air transport of wheelchair batteries, by W.F. McCaffrey, TES Limited. TP 3210E

Compendium of transportation equipment for disabled persons, by B.A. Smith and R.S. Nishizaki, Transportation Development Centre. TP 3618

Multimodal wheelchair securement/passenger restraint: prototype development, by U. Rutenberg, Les Designers Douglas Ball Inc. TP 3057E

Protective container for wheelchairs: feasibility study, by J. Nicklin, Davis Engineering Ltd. TP 3180

Transportation in Canada: a guide for travellers with special needs = Les transports au Canada: guide pour les voyageurs ayant des besoins spéciaux, 2nd edition, 2ième édition, by/par Transportation Development Centre/Centre de développement des transports. TP 380

Wheelchair access system for intercity buses, by D.K. Woods, T. Van Hunbeck, TES Limited. TP 3186

1982

Protective container for wheelchairs: prototype build, by J. Nicklin, Davis Engineering Ltd. TP 3491E

Transit Vehicle for the Disabled, phase I: definition of requirements, by M. Gravel, DeLCan. TP 3523

Transportation for the mobility disadvantaged — technology program = Transports des personnes à mobilité réduite — études techniques, brochure, by/par Transportation Development Centre/Centre de développement des transports. TP 2620

Other

1971 - 1982

Canadian transportation activity and expenditures, 1960-1970, by Acres Consulting Services Ltd., 1974. TP 2221

CDT répertoire des projets, par CDT, (annuel), 1977- . TP 1936F

Contracting out the project monitoring function in TDC, by D.P. Deziel, W.G. Wood and A.R. McGillivray, Hickling-Partners Inc., 1980. TP 2729

Exposé sur le CDT = Profile of TDC, brochure, par/by Centre de développement des transports/Transportation Development Centre. TP 2739

Impartition de la fonction d'agent principal de projet relevant du CDT, par D.P. Deziel, W.G. Wood et A.R. McGillivray, Hickling-Partners Inc., 1980. TP 2729F

Normes de publication destinées aux contractants, par CDT, 1980. TP 929F

Memorandum of understanding between the Department of Transportation of the United States of America and the Ministry of Transport of Canada concerning research and development cooperation in transportation, a status review 1970-1980. TP 2658

Post completion evaluation of five TDC projects, by R.F. Webb Corporation, 1980. TP 2652

Profile of TDC = Exposé sur le CDT, brochure, by/par Transportation Development Centre/Centre de développement des transports. TP 2739

☒ Provincial and municipal policies: access to airport vicinity, by V. Setty Pendakur et al., TDA, 1976.

Publication standards for consultants/contractors, by TDC, 1979. TP 929

Publications du CDT 1971-1982, par CDT. TP 2602

Résumés de projets entrepris par des centres de recherche sur les transports dans les universités canadiennes = Summaries of projects undertaken by centres of transportation studies at Canadian universities, par/by J.M. Morgan, CDT/TDC, 1980. TP 1808

☒ Strategic direction for TDC for 1979/80 by Peat, Marwick & Associates, 1978. TP 1954

☒ Study of provincial and municipal policies regarding ground access to major development in the vicinity of airports in the province of Ontario, by N.D. Lea & Associates Ltd., 1972.

Summaries of projects undertaken by centres for transportation studies at Canadian universities = Résumés de projets entrepris par des centres de recherche sur les transports dans les universités canadiennes, by/par J.M. Morgan, TDC/CDT. TP 1808

TDC project directory, by TDC, (annual), 1977- . TP 1936

TDC publications 1971-1982, by TDC. TP 2602

☒ Transportation equipment industries: the Canadian R&D environment, by M.E. Kieran, TDA, 1972.

☒ Transportation R&D in Canada 1972: an inventory and cross-reference of activities, by TDA, 1972.

Transportation
Development Centre
1000 Sherbrooke St. W.
Suite 2421
Montreal, Quebec
H3A 2R3
Tel.: (514) 283-7504
Telex: 05-24713

Canada